Popular Astronomy.

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RECENT ASTRONOMY.

WM. W. PAYNE.

Some interesting things have recently occupied the attention of astronomers that may rightly claim our attention at this time.

The work at Lowell Observatory, Flagstaff, Arizona, in the study of the surface markings of some of the planets is especially prominent. We have before given brief notices of observations made at that place pertaining to the planets Mercury and Venus, but the details of observations showing what has been seen in recent months we have been unable to give until now. The accompanying cut will show exactly what the observers at Flagstaff unhesitatingly believe to be a true representation of the surface markings of the planet Venus as seen at the times indicated in the drawings. This cut is taken from the *Monthly Notices* of the Royal Astronomical Society, Vol. 58, No. 7, and, in that publication, accompanies an important article on the same subject by A. E. Douglass, astronomer at Lowell Observatory. The article referred to is written with care, and carries throughout a tone of certainty in statement which is intended to disarm criticism undervaluing some results recently obtained by the Flagstaff observers.

In the following paragraph Mr. Douglass offers a fair test for a critic to have in mind when he is ready to declare that markings on the surfaces of planets do not exist, for example, because he has not been able to see them. The paragraph is as follows:

"In the last six years many thousands of hours have been spent by us at telescopes of 13, 18 and 24 inches aperture and their smaller finders, when the seeing was sufficiently good for profitable work on the finest known planetary detail. Expressed in standard terms, the seeing was practically always such that in a 6-inch aperture the spurious disc of the interference pattern was well defined, and a very large part of the time the rings of the same pattern were unbroken. I consider that any astronomer who can not say the same thing for the seeing during his hour of work, and whose hours of work do not reach a commendable number, has no right to criticise our results, for he lacks the experience by which alone he becomes capable of judging."

THE ASTRONOMICAL OBSERVATORY OF THE UNIVERSITY OF

Mr. Douglass claims that the markings shown in the accompanying cut "under proper conditions of air and aperture" are absolutely certain; that in best seeing they are visible at the first glance.

Our readers will naturally wonder why other astronomers have not seen these markings as well as the Flagstaff observers. Other instruments are certainly larger, and probably equal to the Flagstaff equatorial in defining power. Other astronomers have experience and the trained eye. Why have they not seen them? This and other like questions are very natural, and yet no such queries with all their implied answers furnish good ground for objection to the results of work done at Flagstaff, especially that now under consideration. The studies and experience of Schiaparelli, of Italy, in 1878 and later, in regard to his discovery of the "canals" of Mars is a case, in science, which ought to be a lesson to astronomers generally. The work of Schiaparelli was ridiculed by astronomers on the continent and in different parts of the world with unsparing and unstinted severity. In some cases the truth-loving integrity of these apostles of science overdid itself and reacted in favor of the persecuted young Italian, so that the truth in regard to his work had a chance for its life, within the first ten years after discovery, though scarcely much more could be claimed for it. What was the matter? Was Schiaparelli wrong in his claims? By no means. Every amateur now knows he was right, and that he had not, at first, seen the half of the wonders of the Martian surface that were revealed to him later, as a reward for his patience and skill. Other astronomers ridiculed him because he saw with a seven inch instrument what others could not see with larger telescopes even though they were told of the existence of the "canals" and how they looked.

Though we do not yet certainly know, we are of the opinion that this bit of interesting history is repeating itself, in regard to the work at Flagstaff. Mr. Lowell's results on the study of Mars obtained in 1894-5 and published in book form three years ago, and his work with that of Professor William H. Pickering and A. E. Douglass on the surface marking of Mars, Venus and Mercury and the satellites of Jupiter furnish examples of what we mean. It may be that these able men have sometimes misjudged the meaning of what they saw, and have drawn conclusions that were partially erroneous, in consequence of the lack of sufficient evidence to shut out all reasonable doubt; yet, that they are right in the main, that they have been scientifically careful in their work, and that they are worthy of confidence and of praise

for the noble work they have done for astronomy, we have not the slightest doubt. This publication has always believed in those scholarly men, and it has aimed to give them full and deserving credit for that which they have done in the study of planetary details. The theme is an exceedingly difficult one, its successful study is largely new, and advancement in it is, and should be, most welcome to all. When astronomers, (we mean the older ones as well as the amateurs) learn how to observe successfully for the study of fine planetary details, there will be less of unworthy criticism, and immensely more advantage in coöperative labor which ought to be useful in this line of study as well as in others.

Another paper by Mr. Douglass has recently appeared in the *Astronomische Nachrichten*, which is titled The First Satellite of Jupiter and connected with that article appears a full page plate illustrative of the drawings made while observations were going, between the dates of Feb. 18 and June 9, 1897. The instruments used were the Clark 24 inch refractor and the Grubb 15-inch telescope of the Mexican National Observatory. The places of observation were in Mexico and in Arizona.

Since Professor William H. Pickering's work in 1893 on the satellites of Jupiter, at Arequipa, Peru, the attention of astronomers having sufficient power of instrument has been given to the physical study of these interesting bodies. Professor Pickering then made the unexpected statements, that the first satellite was of small density from a quarter to half less than the others, that its rotation was retrograde, and that it was elongated in shape, probably revolving about its major axis instead of the minor axis of figure as usual.

In Nov. 1893, E. E. Barnard, then at Lick Observatory, made some important observations respecting the first satellite of Jupiter, by the aid of the 36-inch equatorial, which were published in the Jan. number of the *Monthly Notices* of the Royal Astronomical Society for the year 1894. In that article Mr. Barnard speaks of the polar caps of the satellites as "heavily marked and quite dark," while its equatorial belt was bright and very conspicuous." From these observations Mr. Barnard concluded that this satellite rotates on its axis in less time than it revolves around Jupiter, that its axis is nearly perpendicular to its orbit, and that the southern polar cap is sometimes a little smaller than the northern one. In this paper Mr. Barnard's attention was chiefly given to the dark caps and bright central belt of the satellite and probably not so definitely to the rotation time. In

Mr. Douglass' last paper he especially considered the size of the satellite, its rotational velocity, and its polar compression. In regard to these features, and after a full discussion of his observations and a comparison of his results with those of Mr. Barnard and Professor Pickering, shows a decrease in the size of the satellite, and an increase in rotational velocity and an increase in mean polar compression. The accepted mean diameter of this satellite has been 2500 miles, that arrived at by Mr. Douglass is very nearly 2000. This paper with its accompanying cut though not quite complete in all particulars is useful and timely.

Another paper in No. 7 of the *Mohthly Notices* of the Royal Astronomical Society for this year will catch the attention of astronomers everywhere for several reasons. It is found on page 392 under the title, Photographs of the Nebula in the Pleiades, of stars in the surrounding regions and of spurious nebulosity. It is by Isaac Roberts, the well known author, who has, from time to time, published much interesting work in the line of stellar photography. This article is brief, covering less than six pages and is accompanied by a full page plate, the upper half of which is a photograph of the Pleiades by the aid of his 20-inch reflector, with an exposure of ten hours, and the lower half is a photograph of the same group of stars with wider field, by the aid of a 5-inch lens, and the same time of exposure. The reproduction is by the half-tone process with very fine screen, printed on heavy plate paper, in the use of good ink. This reproduction is made from a positive copied from the original negative, probably, so the stars are white and the background black. In so long an exposure the details of brighter objects would be lost of course, and the fainter celestial features of the star field ought to appear more strongly than in exposures of less time if the photographic work is well done in every particular. The reproduction for two reasons can not possibly show what is to be found on the original negative. Practical photographers know that, in every process of copying negatives, some of the details of the original are lost. This is certainly true of the very best known means of reproduction. Not all ways of copying are equally good, for some are more effective in securing details from the original than others. The half-tone process is not equal to some others in this regard, although the picture before us is an excellent specimen of art of its kind, for it shows a multitude of fine star points and a distribution of them in the field that may be verified easily.

Turning now to Mr. Roberts' description of these photographs we find much of interest, because the field is somewhat familiar.

PLATE VI.

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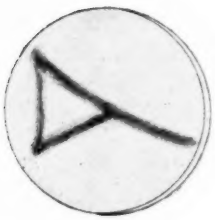
1



DETAIL SEEN IN EACH COMBINATION OF APERTURE AND FOCUS, SAVE ONE, 1898 APRIL 19.

S

2

DETAIL DRAWN 1898 APRIL 19 10^h 47^m G, M. T.

S

3

MR. DREW'S DRAWING OF 1898 APRIL 19, 13^h 5

VENUS —LOWELL OBSERVATORY, FLAGSTAFF, ARIZONA.

POPULAR ASTRONOMY, No. 56.

Comparing the negatives of Dr. H. C. Wilson, of this Observatory, taken in 1894 (and at other times) with the Clark 8-inch photographic telescope and also with the 6-inch Brashear photographic camera, we easily follow what he particularly gives as the results of the ten hour exposure above referred to. The nebulosity about Merope is well described both in character and extent. The brighter portion of it is filled with streaks and lanes that stand out as prominently as any other nebulous matter in the cluster. In our photographs the definition of the streaks falls off more rapidly than the density of the nebulosity as the faint outlying parts of the nebula are reached. The images of all small stars within the nebulosity are quite perfect. The Merope nebula seems to be quite uniform in character throughout, except in the one particular just named, where it seemed to us that the faint streaks are replaced by irregular cloud-like masses. The time of exposure of this negative was 4 hours.

In his description of this nebula Mr. Roberts makes no mention of the new Merope nebula which some American astronomers claim to see visually with instruments of large aperture. We do not know the position of the new nebula and so are unable to say whether or not the photographic plates of this Observatory will give any evidence of it. It is not certainly prominent as compared with other nebulosity on our negatives. "The straight streak of dense nebulosity" which crosses stars 1 and 7 (Bessel), involving other faint stars also is a curious and somewhat common feature in this star group. Mr. Roberts suggests that it may be an independent nebula seen edgewise. This would be a very natural way of thinking of the matter, if there were not so many similar streaks elsewhere found in other parts of the star group. If Mr. Roberts is right in thinking that the nebulosities of Alcyone, Merope and Maia, and probably other stars are wholly independent of one another, and are no way physically related, it would certainly be natural to think of the streaks above referred to as also independent, and possibly masses of nebulous matter seen by us edgewise as before stated.

The very strong double streak that passes by Electra and quite parallel to the other passing through stars 1 and 7 just mentioned, is certainly one of the most singular cases of nebulous disposition which we have here to record. It seems scarcely possible that we are here to think of two other nebulæ parallel to each other and both parallel to a third and all placed edgewise to our line of view. Exactly the same thing might to be said of another streak between Alcyone and Electra that is crossed by a

dense part of the Alcyone nebula. These nebulæ do not disturb one another at all as Mr. Roberts suggests, and in this way his view of independence is apparently confirmed. It does not seem to us that he is right in saying that Electra is not involved in nebulosity. On the same negative that we see the flocculent and streaked nebulosity about Alcyone and the deeply striated masses about Maia with lines extending to Asterope and beyond, we also find faint flocculent nebulosity near Electra, especially between the streaks through stars one and seven, and the dense one passing by Electra. This nebulosity seems to us as certain as some parts of the streak that passes near the star.

The last three pages of Mr. Roberts article in which he speaks pointedly of E. E. Barnard's photograph of the Pleiades group are a real surprise. On account of Mr. Barnard's practical knowledge of photography from boyhood, and from an experience of fifteen years in astronomical work of this kind that has stood the test well in this country, we have thought that he could not be wholly mistaken, when he says repeatedly in public that there can be no doubt whatever that nebulosities exist, which lie far outside and around the Pleiades group.

We think we have a little evidence to offer from photographs taken at Goodsell Observatory. One exposure made in 1895, October 23 9^h 15^m to 13^h 15^m, Oct. 24 7^h 45^m to 9^h 45^m, Oct. 26 9^h 15^m to 14^h 30^m, making a sum total of exposure of one plate in the three days of eleven hours and fifteen minutes. This negative was made by Dr. Wilson using the Brashear 6-inch camera attached to the 8-inch photograph telescope. The focal length of the camera is 30 inches and the plate used was 8x10 inches "Cramer lightening." The Pleiades group is at the center of the negative and the field covers a circular area of 16 degrees in diameter. Starting from the star Maia and extending outward in spiral form is a broken stream of nebulosity that may be followed for more than eight degrees. In the field near the Pleiades the stream encloses a group of stars more than half a degree in diameter, and then narrowing for about one degree it sweeps around a curious whirlpool cluster of stars for a little way, and breaks up in irregular patches until lost to view. This is but one instance of the outlying nebulosities in the field surrounding the Pleiades which seem to me certainly traceable on the negatives above referred. Others might be given, but it does not seem necessary for our purpose at this time.

As before said, it is a surprise to us that Mr. Roberts should be so positive that none of these outlying nebulosities exist simply

because the several negatives which he has taken do not show them. It is doubtless entirely true that favorable,—may be very favorable—circumstances attended the exposure of his plates as he suggests. Is it not also *possible* that he might not get these faint nebulosities notwithstanding he might well expect them? Our own presentation of this matter would be much stronger if we had Mr. Barnard's negative before us for a comparison so that we might note coincidences or differences between the negatives taken by two different instruments under wholly different circumstances. If the negatives were found to agree substantially, such testimony would be conclusive. We have little doubt but that this will be done soon, so that the important question whether the nebulosities in the region of the Pleiades exist or not may be a little more definitely settled if possible.

We are always a little shy of strong negative assertions of this kind because there are so many chances to be mistaken. One noted photographer some years ago claimed positively that it was impossible to photograph more than the naked eye could see. He has since changed his mind. Another good photographer now says the so-called Merope nebula does not exist. He has not seen it, therefore he does not believe it. It is needless to say that the last question was settled by photography ten years ago. The great astronomer is always a very modest man.

THE ASTRONOMICAL OBSERVATORY OF THE UNIVERSITY OF ILLINOIS.*

G. W. MYERS, PH. D., DIRECTOR.

FOR POPULAR ASTRONOMY.

During the legislative session of 1895, the sum of fifteen thousand dollars ($15,000.00) was appropriated to build and equip a students' astronomical Observatory for the university. Through unavoidable delay at the outset, no contracts were let until the Spring of 1896. In April of this year however, ground was broken for the Observatory building and about the sametime contracts were let by I. O. Baker, professor of civil engineering, to whose supervision the erection of the building and purchase of equipment had been entrusted, (the writer being then absent in Europe on leave) to Warner & Swasey for a 12-inch equatorial telescope, 3-inch combined transit and zenith telescope and a high grade chronograph.

* See frontispiece to this number.

From Sægmueller, the following were purchased: A 4-inch equatorial, a 2-inch transit and a cheap chronograph.

The last of these instruments was delivered to the Observatory during the latter part of February, 1897, and they are all their makers claim for them.

Since the above purchases there have been added to the equipment a Riefler sidereal clock, a standard Green's barometer and three Green's thermometers with various minor apparatus and appliances for facilitating the work of observation and instruction in both theory and practice.

The University previously owned three chronometers, two sextants, a 2-inch Troughton and Simms altazimuth, a 4-inch Newton and Co. equatorial, a 1½-inch Newton and Co. transit and two artificial horizons.

These now constitute a part of the astronomical equipment.

The Observatory building is situated on a little knoll about five minutes' walk south of University Hall and commands as good a horizon as can be had in the neighborhood. It is constructed of terra cotta repressed brick, faces the north and in plan, has the form of the letter T. The accompanying half tone represents quite well its general appearance viewed from the northeast and the plan gives the dimensions and arrangement of parts of the building.

The bar of the T is 74 feet long east and west by 25 feet wide. The stem extends from the middle of the south line of the bar 26 feet to the south. From the intersection of the stem and bar rises a tower of masonry, octagonal in plan to a balustrade surrounding it at an altitude of 25 feet, whence it continues, circular in plan to an altitude 10 feet higher. The tower is capped by a circular stone plate carrying the track on which rolls the dome. The balustrade opens toward the south on an observing deck 30 feet squure.

The internal diameter of the dome is 24½ feet and rises, at its apex, to a height of 24 feet above the floor of the equatorial room. It revolves upon trucks, rolling on a circular rail and is turned with the hand, by means of a rope and sheave. The slit has 44 inches clear opening, extends beyond the zenith and is closed by a single shutter. The latter travels on rollers at the ends of its arc and may be completely opened or closed in 5 seconds.

The east and west wings of the building contain each two transit rooms, provided with slits 26 inches wide in the sidewalls and roof. The openings in the side walls are closed by windows which drop into pockets below. Each slit has an isolated pier

placed centrally under it. The 1½-inch Newton transit is mounted in the west room, the 2-inch Fauth transit in the west central; the 3-inch combined transit in the east central room and the alt-azimuth usually sets on the eastern pier.

The Riefler clock is mounted on a pier in a small room adjoining the 3-inch transit room and so located that its face may be seen from the eye end of this instrument.

The chronographs are placed in a second small room just south of the clock room and adjoining it.

The room under the equatorial is occupied by cases for books, chronometers and portable instruments, while the south room is used as a lecture, recitation and computing room.

The building, as also the verniers and position micrometer of the large equatorial are illuminated by the city electric lines and chronographic records are made by means of batteries kept in the basement.

The alternating current used to illuminate the building having a voltage of 110, it was found necessary to cut it down greatly to utilize it for the small 9 volt lamps of the verniers of the hour and declination circles and micrometer. By an arrangement of switches, converter and choke coil, devised by the electrical engineering department, this current is made to subserve all these purposes. The scheme is thoroughly satisfactory and can be recommended as a simple and easy means of removing the necessity of batteries requiring frequent attention.

UNIVERSITY OF ILLINOIS, Urbana, Ill.,
March 21, '98.

THE ASTRONOMY OF SHAKESPEARE.*

ORRIN E. HARMON.

FOR POPULAR ASTRONOMY

THE STARS AND CONSTELLATIONS.—Shakespeare occasionally speaks of some of the fixed stars and constellations.

Falstaff is not only wit and philosopher, but in a mild way an astronomer.

In the conversation between him and Prince Henry, already referred to in speaking of the Moon, the "greasy knight" says:

> "We that take purses go by the Moon and Seven Stars and not by Phoebus."
> First Part Henry IV, Act I, Sc. II.

* Continued from p. 268.

Also Lear's fool mingles the "Seven Stars" in his talk with the King:

"The reason why the Seven Stars are no more than seven is a pretty reason."
Lear, Act I, Sc. V.

Virgo, Taurus and Aries are spoken of in Titus Andronicus (Act IV, Sc. III) and though the reference is decidedly mythological, yet there is a strong hint that Shakespeare knew of the starry constellations by that name. But in the following passage, we are not left in any doubt about his acquaintance with the constellations of the zodiac:

"That were to enlard his fat already pride
And add more coals to Cancer when he burns
With entertaining great Hyperion."
Troilus and Cressida, Act II, Sc. III.

So also this expression refers to Taurus as a constellation:

"What shall we do else? Were we not born under Taurus?
Twelfth Night, Act I, Sc. III.

The Great Bear is mentioned twice, but under different names—Charles' Wain and Ursa Major:

"Charles' Wain is over the new chimney, and yet our horse not pack'd."
First Part Henry IV, Act II, Sc. I.

Edmund says:

"My nativity was under Ursa Major; so that it follows I am rough and lecherous." Lear, Act I, Sc. II.

Edmund's words are spoken in irony, as will be seen by reading the entire text.

There is also reference to the "burning bear," and "the guards of the ever-fixed pole" in Othello, Act II, Sc. I.

Shakespeare knew that the north pole of the heavens is the fixed point about which the stars seem to revolve; and the fame of the North Star was well known to him.

"When yond same star that's westward from the pole
Had made his course to illume that part of heaven
Where now it burns." Hamlet, Act I, Sc. I.

"If her breath were as terrible as her terminations,
there were no living near her;
She would infect to the North Star."
Much Ado About Nothing, Act II, Sc. I.

Cassius beseeches Julius Cæsar to repeal the banishment of Publius Cimber. Cæsar, proud of his fame, and desiring to show his firm determination, compares his glory and constancy to the North Star.

"I am constant as the northern star,
Of whose true-fix'd and resting quality
There is no fellow in the firmament.
The skies are painted with unnumbered sparks;
They are all fire and every one doth shine.
But there's but one in all doth hold his place;
So in the world." Julius Cæsar, Act III, Sc. I.

Cæsar's majestic language becomes tragically serious, when it is remembered that his words were spoken just before his assassination.

ASTROLOGY.—Shakespeare's writings, so far as they concern the heavens, are so mixed with astronomy and astrology, that it seems impossible to treat fully of the former without touching upon the latter.

His mention of eclipses, comets and meteors is nearly always colored with astrology, and we have seen that the same is largely true of the planets. He makes most of his characters believe in astrology, although there is now and then an exception.

Kent says:

"It is the stars,
The stars above us govern our conditions."
Lear, Act IV, Sc. III.

And Gloucester says:

"These late eclipses of the Sun and Moon portend no good to us."
Lear, Act I, Sc. II.

The following passages are in the same tone:

"And wherefore gaze this goodly company,
As if they saw some wondrous monument,
Some comet or unusual prodigy?"
Taming of the Shrew, Act III, Sc. II.

Bedford, lamenting the death of Henry V, exclaims:

"Comets, imparting change of times and states,
Brandish your crystal tresses in the sky,
And with them scourge the bad revolting stars
That have consented unto Henry's death!"
First Part Henry VI, Act I, Sc. I.

Calpurnia tries to keep Julius Cæsar away from the capital by pointing to the portends in the heavens:

"When beggars die, there are no comets seen;
The heavens themselves blaze forth the death of princes."
Julius Cæsar, Act II, Sc. II.

And in Hamlet, Horatio refers to the evil signs in the heavens, little before Cæsar's death:

"Stars with trains of fire and dews of blood,
Disasters in the Sun; and the moist star
Upon whose influence Neptune's empire stands
Was sick almost to doomsday with eclipse."
Hamlet, Act I, Sc. I.

Hermione says:

"There's some ill planet reigns;
I must be patient till the heavens look
With an aspect more favorable."
Winter's Tale, Act II, Sc. I.

And Ulysses, philosophic as he was, indulges the fancy:

"When the planets
In evil mixture to disorder wander,
What plagues and what portents!"
Troilus and Cressida, Act I, Sc. III.

Meteors mingled their terrors with comets, and with unusual appearances of the Sun and Moon:

"The bay trees in our country are all wither'd
And meteors fright the fixed stars of heaven;
The pale fac'd Moon looks bloody on the Earth
And lean look'd prophets whisper fearful change."
Richard II, Act II, Sc. IV.

"This shower, blown up by tempest of the soul,
Startles mine eyes, and makes me more amazed
Than had I seen the vaulty top of heaven
Figured quite o'er with burning meteors."
King John, Act V, Sc. II.

But in the following passage the planets have shed their kindly influences:

Antiochus, praising the virtues of his daughter, says:

"The Senate-house of planets all did sit,
To knit in her their best perfections."
Pericles, Prince of Lyre, Act I, Sc. I.

Now let us hear the talk of some characters who did not believe the superstitions of astrology.

Cassius says to Brutus:

"The fault, dear Brutus, is not in our stars,
But in ourselves, that we are underlings."
Julius Cæsar, Act I, Sc. II.

And Edmund does not blame the heavens for his disgraceful birth:

"This is the excellent foppery of the world, that, when we are sick in fortune—often the surfeit of our own behavior—we make guilty of our disasters the Sun, the Moon, and the stars. * * * I should have been that I am, had the maidenliest star in the firmament twinkled on my bastardizing."
Lear, Act I, Sc. II.

Coming to Shakespeare's personal opinion, we have seen that he confesses he had astronomy, but not to tell of good or evil luck. (Sonnet XIV).

POETRY OF THE HEAVENS.—Shakespeare tells us:

"The poet's eye, in a fine frenzy rolling,
Doth glance from heaven to Earth, from Earth to heaven."
Midsummer Night's Dream, Act V, Sc. I.

Some of the thoughts that came to him through his glances at the heavens, have been given in the foregoing pages.

These thoughts have been stated more with regard to the scientific aspect of the heavens than with regard to their poetry. Though many of the passages already cited contain good poetry, I desire in conclusion to extend this feature of our subject a little further.

Shakespeare has enchanted the world with his wonderful pictures of human character. However strong our admiration for him in this respect, our admiration passes into sublime reverence when we are brought under the spell wrought by his highest poetical flights. It is a remarkable fact that when he wished to arouse the finer feelings of our nature, he found no materials more useful to him than the Sun, Moon and stars.

Proteus, to show how his love for Julia has passed to a higher love for Silvia, says:

> "At first I did adore a twinkling star,
> But now I worship a celestial sun."
> Two Gentlemen of Verona, Act II, Sc. VI.

Cleopatra turned to the heavens to find fit expression of her admiration for Antony:

> "His face was as the heavens; and therein stuck
> A Sun and Moon, which kept their course and lighted
> The little O, the Earth."
> Antony and Cleopatra, Act V. Sc. II.

Charles the Dauphin, addresses these words to Joan of Arc when she assures him that she will raise the English siege at Orleans:

> "Bright star of Venus, fallen down on the Earth,
> How may I reverently worship thee enough?"
> First Part Henry VI, Act I, Sc. II.

What a strong figure is this showing the approach of night:

> "The dragon wing of night o'erspreads the Earth."
> Troilus and Cressida, Act V, Sc. IX.

And this, picturing the dawn of day:

> "Night's swift dragons cut the clouds full fast,
> And yonder shines Aurora's harbinger."
> Midsummer Night's Dream, Act III, Sc. II.

The beauties of the morning and the evening come to Shakespeare when he wished to describe the eyes that won his love:

> "And truly not the morning Sun of heaven
> Better becomes the grey cheeks of the east,
> Nor that full star that ushers in the even
> Doth half that glory to the sober west,
> As those two mourning eyes become thy face."
> Sonnet, CXXXII.

As Romeo sees Juliet standing at her window, he exclaims,

"But soft! What light through yonder window breaks?
It is the east and Juliet is the Sun.
Arise fair Sun, and kill the envious Moon,
* * * * * * * * *
Two of the fairest stars in all the heaven,
Having some business, do entreat her eyes
To twinkle in their spheres till they return,
What if her eyes were there, they in her head?
The brightness of her cheek would shame those stars,
As daylight doth a lamp; her eyes in heaven
Would through the airy region stream so bright
That birds would sing and think it were not night."
Romeo and Juliet, Act II, Sc. II.

Juliet vies with Romeo in singing her love, and she looks to the stars for the imagery of her thoughts:

"Come, gentle night, come loving, black-brow'd night,
Give me my Romeo; and, when he shall die,
Take him and cut him out in little stars,
And he will make the face of heaven so fine
That all the world will be in love with night."
Romeo and Juliet, Act III, Sc. II.

Nothing in Shakespeare is finer than Lorenzo's talk to Jessica, as they look upon the heavens:

"Look how the floor of heaven
Is thick inlaid with patines of bright gold:
There's not the smallest orb which thou behold'st
But in his motion like an angel sings,
Still quiring to the young-eyed cherubims;
Such harmony is in immortal souls;
But whilst this muddy vesture of decay
Doth grossly close it in, we cannot hear it."
Merchant of Venice, Act V, Sc. I.

LIBERAL, Barton Co., Missouri.

METEORIC SHOWER OF NOV. 13, 1897.*

W. H. PICKERING.

It may, in this connection, be pointed out that Meteor I was red or orange colored, while Meteor II was white. The first one appeared to me to be of the color of a sodium flame. Both penetrated the atmosphere to about the same depth, and both were clearly Leonids. These facts go to show that the difference in color is not due to a grazing contact with our atmosphere in some cases, and a correspondingly low temperature, but to an actual difference in the chemical constitution of the individual meteors which compose the swarm.

* Continued from page 298.

The method hitherto adopted of computing the size of the meteors depends on comparing their brightness with that of a standard candle. A ratio is then assumed between the fraction of the total energy of the candle converted into light, and the corresponding fraction of the total energy of the meteor similarly converted. The result obtained is that the majority of the meteors seen weigh less than a single grain. This assumed ratio is not known within several hundred per cent, the other quantities are very uncertain, and the result appears extremely improbable. A more direct, and it is believed a more accurate, result may be derived from a simple comparison of the meteors with an electric arc light. The meteors can hardly be heated above the boiling points of the substances of which they are composed. These boiling points are in general lower than that of carbon. The intrinsic brightness of the meteor must therefore be less than that of the cup in the arc light, and probably does not exceed that of the brightest portions of the external surface of the carbons.

It is true that the gaseous pressure in front of the meteor is doubtless very high, which would tend to raise the boiling point, and in consequence the intrinsic brilliancy, of the heated mass, but it is thought that for the following reasons this will not seriously affect the final result. If we project the image of an arc light upon a screen in a darkened room, we shall find that the light comes almost exclusively from the two brilliant carbons, which are separated by a faint violet glow, which is the arc proper. If for the screen we substitute a photographic plate, we shall find upon development, that the relative brilliancies are now reversed, and that the carbons are comparatively faint, while the arc and a small area of the carbon on which it plays are intensely actinic. In other words the solid carbons, although far more brilliant to the eye than the incandescent gases of the arc, are not heated hot enough to strongly impress the photographic plate. The spectroscope gives an analogous result, the marked feature of the arc spectrum being the three strong bands due to carbon vapor, while the continuous spectrum due to the incandescent carbons is comparatively faint. In circular No. 20 published by this Observatory is given a description of the only spectrum of a meteor yet photographed. The characteristic feature of this spectrum is the bright lines due to the incandescent gases with which it is surrounded, and not the comparatively faint continuous spectrum of the incandescent solid itself. Similar results are presented by some sunspots, and some of the fainter stars whose spectra have been photographed. On the other hand in the case

of the Sun and the brighter stars, the continuous spectrum is much brighter than that of the incandescent gases, which appear dark by contrast. The relative brightness of the lines and of the continuous spectrum therefore furnishes us with a crude test of the absolute temperature. From its spectrum, therefore, we conclude independently that notwithstanding the high gaseous pressure, the temperature and intrinsic brilliancy of a meteor are analogous to that of an arc light, and not at all comparable to that of the Sun.

Recent observations made with the meridian photometer upon three street arc lights situated nearly due north of the Observatory, at distances of 2.44, 2.38, and 2.50 km., showed that their light was much more steady and uniform than might have been expected. Their photometric brilliancies were — 1.0, — 0.4, and — 1.0 magnitudes. We may therefore assume that if without globes and burning freely, at a distance of 2.5 km., they would give a light equal to that of a star of magnitude — 1.0. To be reduced to the magnitude 3.0, or to the brightness of an average meteor they must be at a distance of 15.5 km.

We may take the luminous area of the carbons as equal to that of a circle about 12 mm. in diameter. It therefore appears that a meteor of the magnitude 3.0, at a distance of 15.5 km. would be 12 mm. in diameter, so that at a distance of 200 km. it would have a diameter of 160 mm., and if its specific gravity were that of iron, 7.8, it would weigh 16 kgm. or 35 pounds avoirdupois. The larger Leonids seen upon this occasion would weigh several hundred pounds, and be quite analogous in size to the larger meteoric masses which owing to their slow motion succeed in reaching the surface of the Earth intact. While, therefore, on account of their high speed, we can readily understand why no Leonid has ever been known to reach the Earth's surface, this protecting influence of out atmosphere does not defend us to the same extent from the slower moving Andromedes, and as is well known, upon November 27, 1885, during a shower from this radiant, a piece of iron weighing over eight pounds did actually reach the Earth at Mazapil in Mexico. This fact further strengthens the idea that the individul bodies composing a meteoric shower are masses of considerable size, and not mere grains of sand. To view the subject from another standpoint, however, let us now assume that a meteor of magnitude 3.0 does weigh only one grain. Its weight is therefore only $\frac{1}{245000}$, and its surface $\frac{1}{4000}$ of the values computed above. This would lead to the highly improbable conclusion that the intrinsic brilliancy of such

a meteor would be 4000 times that of the carbons of an arc light, or perhaps 40 times as great as that of the Sun.

The location of the radiant of the meteors observed at Cambridge, as determined by Mr. Wendell from the paths of the eighteen whose points of appearance all lay within 50° of it, was in $\alpha = 9^h\ 59^m$, $\delta = +\ 21°.7$ (1900). No mathematical discussion of the observations was attempted, but the paths as charted were simply prolonged backwards, and the centre of intersection selected by the eye. This position differs chiefly from that given by Mr. Denning in being 1°.2 farther to the south. Of the five meteor trails observed, whose position angle lay between 60° and 120°, but one lay as far north as the radiant given by Mr. Denning. This one crossed the hour circle of $9^h\ 59^m$ in declination $+\ 24°.7$. The other four crossed it in declinations that lay between $+\ 22°.2$ and $+\ 20°.7$. From the paths of the five meteors located within 10° of the radiant point observed by myself from Blue Hill, I deduced a position for the radiant located in $\alpha = 9^h\ 50^m$ and $\delta = +\ 21°.5$. These observations were too few to give results of any value in themselves, excepting in as far as they confirm the declination found by Mr. Wendell. Further evidence regarding the location of the radiant will be found below under the photographic results.

Turning now to what was properly my own department—the photographic work, the first problem that presented itself was the geometrical one, as to the portion of the heavens towards which the cameras could to most advantage be pointed. In this connection the point of first interest perhaps is to determine in what portion of the heavens the maximum number of meteors will be seen. The determination of this position is affected by four different considerations. (*a*) Let us consider first merely a single point on each trail, as for example the point of disappearance of the meteor. It is evident since the meteors would be equally distributed per square mile of surface in the immediate vicinity of the observer, that they would appear least frequently in the zenith, and with equal frequency in all portions of the horizon, their frequency increasing approximately as the secant of the zenith distance. (*b*) Since the meteors disappear at an altitude of forty or fifty miles above the surface of the Earth, the same law of atmospheric absorption of light will apply to them as to the stars. Therefore there is a limiting altitude at which the maximum number will be visible. (*c*) Since the meteors are nearer to us in the zenith than towards the horizon, it is evident that a number of small meteors will appear there which would

not be visible at all in other portions of the sky. This will tend to further raise the altitude at which the maximum number will be visible, but to raise it by an unknown amount. (*d*) Since the meteors appear as lines, and not as dots, it is evident that each one will appear to occupy the most space, and they will as a whole accordingly tend to appear most thickly distributed, in that great circle of the heavens which has the radiant point as its pole. Visually the trail will catch the eye of the observer more or less in proportion to its length. Photographically the smaller the field of the lens, and the longer the mean trail, the more pronounced will be the result produced.

The combined effect of these four results will be that towards the end of the night, when the meteors appear most frequently, the maximum number will be seen in a portion of the heavens whose azimuth is 180° from that of the radiant, and which is situated at only a moderate altitude above the horizon, the altitude varying as a function of the altitude of the radiant. Earlier in the evening the meteors will appear most frequently at two points somewhat to the north and to the south of this azimuth. On the whole an observer of the north-western sky will see the maximum number of meteors throughout the night. In this direction they will leave the longest trails, and have the swiftest apparent motions. The general truth of these conclusions was borne out by the results of the visual observations made at Cambridge, where although there were fewer observers to the west of the meridian than to the east of it, yet by 17^h, 49 meteors had been seen to the west, and only 33 to the east of the meridian. Later 9 more were seen to the east, and none to the west.

But the maximum number visible is not the only point to be considered in photographic work. Since only the very brightest meteors can be photographed at all, it is clear that from that point of view the zenith is the region toward which we should point our cameras. Still another consideration, however, and a most important one, must also affect our choice. The slower the apparent motion of the meteor, the more time it has to affect the plate, and the stronger will be the image produced. The meteors move most slowly at the radiant point itself. Therefore, if we wish to obtain theoretically the greatest number of meteors, we must point our cameras to the west of the zenith, if we wish the brightest meteors we must point them to the zenith itself, and if we wish the slowest moving meteors we must point them to the east of it.

Since the Moon occupied that portion of the heavens where we

wish to point our cameras early in the evening, it was decided to point them at $10^h\ 30^m$ until 14^h to the zenith at both stations, and after that time to point them at the radiant. At Cambridge they were pointed slightly to the south in both instances, and at Blue Hill slightly to the north, so as to allow for the parallax of the meteors. No clockwork was employed. A portrait lens of four inches aperture and 22 inches focus was mounted at each station. At Cambridge two wide-angle lenses of 8 inches focus were pointed to include contiguous region of the sky, and at Blue Hill a wide-angle lens of 6 inches was employed. A pinhole camera pointing at the zenith and including the whole sky within about 20° of the horizon was set up at each station. It was hoped with these latter instruments to secure an impression of any very brilliant fireball that might cross the sky outside of the field of the other cameras. The exposure of the plates in these cameras lasted all night, and was closed at 17^h. The exposures with all the other cameras lasted half an hour, the lenses being capped on the hour and half hour. In no case was the light of the Moon so strong as to fog the plate injuriously, at the same time longer exposures would have been undesirable on account of the motion of the radiant across the field of view. The portrait lenses easily showed 7.0 magnitude stars, while the wide-angle lenses over a circle of about 50° in diameter showed stars of 6.0 magnitude.

It was proposed in case any bright meteor crossed the portion of the sky photographed, to immediately cap the camera for a few seconds, thus making a short break in the star trails to indicate the positions of the stars at the time that the meteor crossed. The objects of the photographic investigations were first, to determine how bright a meteor must be in order to leave a clearly marked trail upon the plates, second, to determine the radiant point photographically, and third, to determine the exact elevation of a few of the meteor trails above the surface of the Earth. Neither of these investigations was entirely successful, but the first and second were partially so. Eighty-one plates were exposed at both stations, but only two meteors were certainly photographed. One of these appeared upon both of the plates taken at Blue Hill, but was quite faint although clearly marked upon the plate taken with the wide angle lens. The total length of the trail was 40′ and for the first half of its course did not exceed in brightness the trail left by a 7.0 magnitude star. It then rapidly brightened and for a distance of 12′ had a brightness equal to that of a 6.5 magnitude star, after which it again grad-

ually faded out. The trail was about 1′ in breadth. A star leaving a trail of this breadth in the declination of the radiant remains shining upon each square minute of its trail for about four seconds. Since the duration of the meteor probably did not exceed two seconds, it shone upon each square minute of trail for a twentieth of a second, and was therefore approximately eighty times as bright as a 6.5 magnitude star. This meteor was therefore probably not far from the second magnitude in brightness, but unfortunately was not seen either at Blue Hill or at Cambridge. The direction of its trail with regard to the radiant would indicate that it appeared shortly after the plate was exposed, which was at $14^h\ 15^m$. An extremely faint trail appears upon this same plate within 40′ of the spot where the stationary meteor II was observed at $14^h\ 16^m \pm$. The size, direction and position is indicated in Figure 2 by the line near the letter P. This meteor was recorded to be of the 3.0 magnitude.

It may be remarked that if the meteors traversed absolutely parallel paths, their radiant at any given time would be, not a surface, but a geometrical point. Practically it is undoubtedly a surface, but we have no means as yet of determining its size. According to Denning, *The Observatory*, 1897, Vol. XX, p. 243, the radiant is "a very well-marked and contracted centre, in fact the best observed Leonids, when their lines of flight are traced back, usually intersect almost at a point." In this respect they differ strikingly from the Andromedes whose radiant is a surface 7° to 10° in diameter. Such being the case, the intersection of even two trails photographed at about the same time should determine it with considerable precision. By previous table we find that the exact time at which Meteor II appeared was $14^h\ 17^m\ 19^s$. The exposure of the photographic plate E 3681 was delayed until $14^h\ 15^m$, and the exposure was closed at $14^h\ 30^m$. It was therefore possible to determine the precise position of the stars when the trail of the meteor was photographed. It was found that the prolongation of the trail crossed the successive hour circles of $9^h\ 57^m$, $9^h\ 58^m$, $9^h\ 59^m$, and $10^h\ 00^m$ in declinations + 22° 12′, + 21° 58′, + 21° 45′, and + 21° 31′, thus confirming both sets of visual observations in indicating that in 1897 the radiant was more than a degree south of the location assigned to it by Mr. Denning. In fact, the trail practically passed through the radiant as determined by Mr. Wendell. Had the other meteor which was photographed, been observed visually at either station, we should have known the time at which it appeared, and thus have obtained another line passing through the radi-

* See last number, page 297.

ant. As it is, we can only say that judging from the assumed position of the radiant, the two meteors must have appeared within two or three minutes of one another, and only in case this meteor appeared as soon as the lens was uncapped could its radiant have been as far north as the position assigned to it by Mr. Denning. If it appeared while I was recording the other meteor, the declination of its radiant must have been between 20° and 22°.

With equally favorable weather, more complete results will undoubtedly be obtained another year, but in the meantime it may be said that it would appear to be extremely improbable that Leonids fainter than a third magnitude should impress themselves upon our plates, even at the radiant point, and that they must have extraordinary brilliancy if they are to be photographed in any other portion of the sky. The meteors whose photographs have hitherto been secured, at Cambridge, Arequipa and elsewhere, were doubtless comparatively slow moving fireballs of very intense brilliancy.

In addition to the photographs already described, four charts of the region of the radiant point, were taken with the Draper 11-inch telescope. Forty-six photographs were also taken with six instruments, fitted with objective prisms whose apertures ranged from three to eleven inches, this portion of the work being under the direction of Mr. King. Three of these plates were taken with the Draper 11-inch telescope with two objective prisms each having an angle of 15°. Fourteen plates were taken with the Draper 8-inch telescope with two objective prisms each having an angle of 6°. Twelve plates were taken with the 6-inch Draper telescope with an objective prism of 6°. Eight plates were taken with the Voigtländer 5-inch telescope with an objective prism of 5°. Six plates were taken with the Darlot Portrait lens, aperture 3 inches, angle of prism 6°. Three plates were taken with the Ross Rapid Rectilinear lens, aperture 1.5 in., angle of prism, 15°. With the exception of the last instrument these telescopes were pointed so as to intercept as many meteors as possible. As the path of a meteor is a straight line, it is best intercepted by photographing regions along a line at right angles to it. As the brightest meteors are seen near the zenith, one point of this line is determined. The instrument was pointed so as to command as much as possible of the portion of a vertical circle near the zenith having an azimuth differing from that of the radiant point by 90°. As two of the instruments were designed to be used near the meridian only, the work was confined to that circle until the Moon interfered,—then the available instruments were directed to

various points around the radiant. This arrangement did not include the Draper 11-inch telescope, which was kept on a region about midway between the radiant point and the zenith. The smalless of the field lessened the chances of photographing a bright meteor with this instrument, but the great dispersion would have given a fine record of such an object if it had passed through the field. Later in the night it was deemed best to remove the prism and to photograph the radiant point, hoping to determine its precise position from any meteors that might be photographed. The examination of the plates taken with these instruments failed to show any meteors, which is not surprising, as nearly all the meteors seen that evening were faint.

The Ross lens was used in a different way. It was attached to a small box camera, which could be held in the hand, and directed quickly to any part of the sky. An index arm fastened to the side of the box guided the observer as to the correction for the deviation of the prism. This instrument did not receive the entire attention of any one observer, but was in readiness for use whenever an observer was free from other duties. The slide of the plate holder was drawn, and the lens lightly capped. No bright meteor was seen by any one while in charge of it. In fact, only the brightest, slow moving meteors could be expected to make an impression, as was shown by three plates taken by directing the camera towards Sirius, Jupiter and the Moon, as if they had suddenly appeared as meteors. Of these, only the Moon appeared on the plate. The exposures however were exceedingly short.

The visual and photographic observations above described were undertaken this year partly to gather information that might be useful in planning the observations of the next few years, and partly to train the observers as to what they might expect to see, as to the best methods of observation, and as to the difficulties that would be encountered. It is thought that the distance between the two stations,—11.7 miles, is rather too large for photographic determinations of parallax, and rather too small for visual work. With stations so far apart, the tracks of meteors that are well photographed at one station are so much spread out as to be invisible or very faint upon the photographs taken at the other. It would appear that three miles would be a very suitable separation when it was possible to employ cameras of fifteen to twenty inches focal length. On the other hand for visual work, such is the comparative inaccuracy of this method, that it seems advisable to have the stations about thirty miles apart, in order to obtain a sufficient parallax to

serve as a basis on which to found satisfactory computations. In either case the stations should lie in a line approximately north and south. It is of little use to point the cameras anywhere save at the radiant point or to begin the photographic observations before midnight.

The best form of lens to employ is undoubtedly a portrait lens of the kind formerly used by photographers. Exposures of half an hour should be given, at the end of which time the camera should again be pointed upon the radiant, or rather upon the region fifteen minutes preceding it. If two cameras are available they should be exposed alternately, so that one or the other should be in use all the time. A simple form of equatorial mounting consists in attaching the camera to point upward from a base, at a fixed angle of 22°, equal to the declination of the radiant. The base is pivoted to turn upon a board placed parallel to the equator. A series of holes, in any one of which a peg may be inserted, serves to adjust the camera in right ascension to any desired hour angle. By this device considerable time is saved in pointing.

Since the meteors present the same characteristics in all portions of the sky, it is better in the case of visual observations, even with a large corps of assistants, to confine the attention strictly to a comparatively small area. Thus, if six or eight observers kept their attention constantly fixed on the region within twenty-five degrees of the radiant point, it is probable that very few meteors would appear in that portion of the heavens that were not seen by at least one of the party. One assistant should be deputed to count the meteors aloud, while another devoted his attention to recording the time of their appearance. Three or four maps should be provided for the observers, and in the case of the bright meteors we might obtain as many independent records of their paths. The path should be designated by the number applied to the meteor by the counter, and a ruled blank should be filled out giving the number, magnitude, color and duration, together with any remarks, and the initials of the observer. In order that no meteors should be missed by the party, the remaining observers should continue to watch the sky until those who had been recording had completed their records, and had again begun observing. Meteors seen by the observers but missed by the counter would be designated by the number last counted, with a subscript letter attached. No meteor should be counted unless some portion of its path comes within the specified region. A general record should be kept of the cloudiness of the sky, besides

an individual record by each observer of the times at which he began and ceased observing.

One advantage of this plan of confining the attention to a small portion of the sky is that the observers may be able to secure a room with a satisfactory eastern exposure, from which during at least a portion of the night the observations may be made in comparative comfort, and with correspondingly close attention, and increased accuracy. As continuous all-night observations are fatiguing, and particularly difficult in cold weather, it might be well for the majority of the party not to begin observing until after midnight, as even in the best years little is to be seen before that hour. If parallax observations are to be undertaken, it is certain that many more complete observations will be secured if attention is confined to a limited area, than if the observations are scattered at random over the whole sky. Moreover, the same constants may be applied to all the computations in one portion of the work, thus affecting a considerable reduction in the amount of clerical labor required.

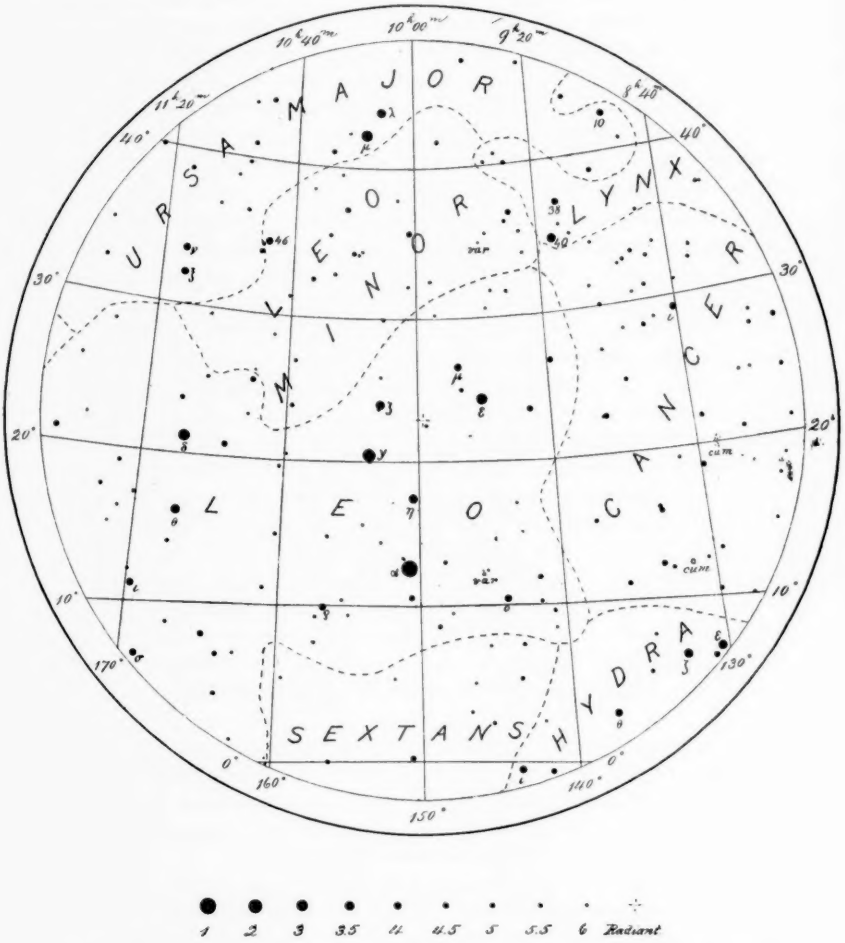
An instrument suggested and designed by Mr. W. P. Gerrish seems to promise valuable results as an adjunct to the visual observations. It was based upon the principle of the nephoscope, and consisted of a plate glass mirror measuring 22 × 28 inches, at the middle of one of the longer sides of which was erected a post carrying an eye stop, which was placed at a height of 15 inches above the surface of the glass. A T-square graduated to centimeters slid the length of the mirror upon a graduated scale, so that any point on the surface of the glass could be rapidly fixed by means of its coördinates. The mirror was placed horizontally, and the positions of a number of the bright stars seen in it were fixed by means of weights whose places were measured, and the time noted. The positions of the points of appearance and disappearance of a number of meteors were similarly recorded, when a comparison of their times with the time of observation of the stars served to definitely fix their position in the sky. It is possible that by means of two pencils or pointed sticks one held in each hand, the points of appearance and disappearance of the meteors could be more accurately designated than by means of weights. In this case, the mirror could be inclined at any suitable angle, provided that it was firmly fixed in place. The services of an assistant would be required to measure the positions. On trial the apparatus apparently worked well, but there was unfortunately no means of testing the accuracy of the paths plotted.

The star chart which we found best suited to our purpose, and

the one which was actually employed in carrying out the above mentioned observations, was that contained in Schurig's Atlas of the Heavens. It seemed, however, that a still better map for our purposes might be secured by means of photography. One great advantage of such a map would be that it would be produced in gnomonic projection, which projection has the advantage that every great circle included in the field would be represented by a straight line. This is a distinct advantage in the plotting of meteor trails, which follow in general arcs of great circles. A photograph was accordingly taken with a No. 5 Morrison wide-angle lens, on the night of December 16, 1897, with an exposure of one hour. Focus of lens 172 mm., aperture of central stop 11 mm. From this negative a reversed glass positive was taken upon double the scale. A bromide print from this positive gave a direct paper negative. Such a negative was not directly suited to our purposes however, for in the first place the star images were too small to be readily seen at night, and secondly, on account of the color of the stars their images were not of the same relative size photographically and visually. The paper negative was, therefore, stretched over a piece of drawing paper upon a board, and the hour circles and declination parallels inserted by means of the positions of the stars. Every star within 25° of the radiant, and brighter than the magnitude 6.25, was identified, and its designation inserted upon the paper negative. Only two objects having this brilliancy could not be found. One was the small star cluster in *Cancer*, N. G. C. 2682, there referred to as M 67 Oriani, and the other, the star H. P. 1538, which fell very near the limit of the chart. The variable star *R Leonis Minoris* was within two months of its minimum and therefore did not appear upon the photograph. All three of these objects were inserted on the chart by measurement from the parallels and hour-circles.

The selection of objects brighter than the magnitude 6.25 was based exclusively upon the measurements made with the meridian photometer and published in the Harvard Photometry and in Volume XXIV of the Annals, and upon certain unpublished observations which will appear in later volumes. No objects fainter than this magnitude are included, excepting the two variables, which are sometimes fainter. About thirty stars appear upon the map which either are not given in the Harvard Photometry on account of their faintness, or else if given are marked as slightly fainter than the magnitude 6.25. Subsequent observations have shown that these were all brignt enough to be inserted

on the map, while it has since been found that two or three stars which were bright enough according to the Harvard Photometry, should be omitted. In no case did the errors amount to more than one or two tenths of a magnitude. The map contains in all just 200 stars.



The intersections of the parallels and hour-circles, and the positions of the stars were next pricked through the paper negative upon the sheet of drawing paper. The negative was then re-

moved and the drawing finished by hand. Each star was first marked with the size it should be upon the scale proposed as a standard in these Annals, Volume XXXII, Part I, p. 28. The distinguishing principal of this scale is that the logarithm of the diameter of each image in millimeters increases over that of its predecessor by 0.1. Since only a small range of magnitude was to be included, and since the number of bright stars shown was very small, it was decided that all stars between 0.5 and 1.5 magnitude should be 3.2 mm. in diameter, between 1.5 and 2.5, 2.5 mm., between 2.5 and 3.25, 2.0 mm., between 3.25 and 3.75, 1.6 mm., between 3.75 and 4.25, 1.3 mm., between 4.25 and 4 75, 1.0 mm., between 4.75 and 5.25, 0.8 mm., between 5.25 and 5.75, 0.6 mm., and between 5.75 and 6.25, 0.5 mm. Small clusters and variables are designated by circles whose diameters indicate their magnitude and maximum magnitude respectively. They are further distinguished by the letters *cum.* and *var.* The positions of a few of the brighter stars in the cluster Præsepe are indicated by dots. Only stars of the magnitude 4.25 and brighter have their designations inserted. The drawing was finally reduced by photography to the scale of the original negative, or 3 mm. to a degree in the center of the map, and published in that form. It is believed that this map differs from all of its predecessors in that it contains practically all the stars of the magnitude 6.25 and brighter, and that it contains no fainter individual stars. It is also believed to cover a larger area of the sky than any map heretofore published that has been prepared directly by photographic means.

SOME FACTS ABOUT THE MINOR PLANETS.*

J. K. REES.

The number assigned to a minor planet corresponded exactly with the order of discovery when discoveries were few. This is not the case at present, but it is quite closely so. Now that they are so numerous, some time may elapse before the planet is proved to be a new one. In the meantime another may be discovered and shown to be new before the proofs are in hand as to the first. In this case the first is made last and the last first; for example, Max. Wolf at Heidelberg photographed two planets on

* Extract from a popular address delivered before the New York Acadamy of Sciences March 29, 1897.

the 18th of March, 1892, and one on the 21st; Charlois on the 22d at Nice and Palisa on the 19th at Vienna, each picked up with his telescope a supposed new planet. The last were shown to be new before Wolf's were decided upon. Thus we have

No. 326	by	Palisa,	discovered	March	19, 1892.
No. 327	"	Charlois,	"	"	22, "
No 328	"	Max Wolf,	"	"	18, "
No. 229	"	" "	"	"	21, "
No. 330	"	" "	"	"	18, "

Up to the present time there have been 44 successful observers. Ten of these have discovered 9 or more planets; fourteen have discovered between 2 and 9, and twenty have discovered one each. At the head of the list stand Palisa of Vienna and Charlois of Nice, each credited with 83. Third in order of number discovered comes our own lamented Dr. Peters, of the Litchfield Observatory of Hamilton College, N. Y., with 47; then follows Max Wolf of Heidelberg with 33, and Luther of Dusseldorf and Watson of Ann Arbor with 24 and 22 respectively.

Before the Atlantic cables were laid, and before telegraphic communication was arranged between Observatories, there were several cases of independent discoveries. Of the 422 little planets whose orbits are known, 340 were discovered in Europe, 76 in the United States and 6 in Asia. The 340 credited to Europe are divided as follows: Germany 155, France 158, Great Britain 14, Italy 13. Down to November 28, 1891, when Max Wolf first tried photography, 322 asteroids (as Herschel named them) were discovered by use of the telescope; since the date named only 7 have been added by the same means. Photography has picked up 93 in the last five years. Thirteen little planets were found between 1801 and 1851, 409 since 1851. The year 1892 was the most prolific, 28 being added to the list; of these 4 were by telescope and the rest by photography. 1893 comes next with 27, all but one obtained by the telescope. 1894 brought 20; 1895, 11; 1896, 13. In these statistics we are dealing only with the planets whose *orbits* have been calculated and published.*

The naming of the minor planets has given considerable trouble. Following the old system of naming the major planets and satellites after deities in the Greek and Roman mythologies, the first discovered little planets were called Ceres, Pallas, Juno, Vesta, Astræa, Hebe, Iris, etc. This system was in the main con-

* There are 23 dates on which 2 planets were found; 7 of these cases included the observations of two men; the others of one man. On September 18, 1893, Charlois found 3; September 25, 1892, Wolf got 4, and on January 7, 1896, Charlois at Nice and Wolf at Heidelberg brought down 9 by photography.

tinued until the multitude exhausted the names; then names were given without any system, but always feminine names.

Number (12) discovered by Hind in London was named Victoria; (20) was styled Massalia after the ancient name of Marseilles; so (21), the first asteroid found at Paris was named after the ancient Gallic capital Tutelia; (54) was called Alexandra after Alexander von Humboldt; (67) was found by Pogson at Madras and called Asia; (323) was the first minor planet discovered by photography on December 20, 1891. Max Wolf named it Brucia after Miss Catherine W. Bruce, of New York City, who has done so much for astronomy in an appreciative and generous manner. Harvard Observatory is indebted to Miss Bruce for its new photographic doublet of 24 inches diameter of object glass and about 11 feet focal length. Max Wolf was made happy by a gift from the same source of a fine photographic outfit. Vassar College Observatory owes much to Miss Bruce for instruments. New York City has reason to be proud of its two patronesses of astronomy, Mrs. Henry Draper and Miss Catherine W. Bruce. (325) was christened Heidelberg by Wolf; (327) was a telescopic discovery by Charlois on March 22, 1892. In honor of the proposed celebration of the 400th anniversary of the discovery of America, he called the planet Columbia. (334) was named by Wolf, to do honor to the proud city that created the splendid exposition, Chicago. Wolf has honored California also in naming (341). The last four to receive names are called Elizabetha, Edburga, Bertholda, Zähringia. Quite a number, happily, have not been named yet. In 1849 Dr. Gould proposed to represent the little fellows by numbers inclosed in a ring; this system has been used, though the naming continues.

Just as in the case of the major planets, each minor planet was given a symbol at first, but the rapid increase caused this method of marking to be given up.

The apparent diameter of the largest asteroid is less than one second of arc; to look at it is like viewing a marble $\frac{3}{10}$ of an inch in diameter at the distance of one mile. The best determinations of the diameters of the four largest were made in 1894 and 1895, by Barnard, with the filar micrometer of the 36-inch equatorial of the Lick Observatory. These observations gave the diameters as follows:

(1) Ceres, 485 miles; (2) Pallas, 304 miles; (3) Juno, 118 miles; (4) Vesta, 243 miles.

It is surprising to find Vesta, the brightest of the four, so much smaller; this has been proved to be due to high reflecting power

of the surface. Its reflecting power was found by Barnard to be more than four times as great as that of Ceres, which is the largest.

The rest of these bodies are probably smaller than the four named; some of them no bigger than a terrestrial mountain. A minor planet 12 to 13 miles in diameter would compare with our Earth as a sand particle to a sphere one foot in diameter. A body weighing 200 pounds on the Earth's surface would, on (188) Menippe, weigh less than five ounces. A weight which falls here 16 feet in the first second would there fall ¼ of an inch. A person might there leap to a height of several hundred feet, in which case he could not return in much less than an hour; but "Of such speculations there is no end," as Sir John Herschel remarks.

The mean distances of the asteroids from the Sun differ greatly; Medusa (149) has the smallest mean distance, 21.3 times the Earth's distance from the Sun, or about 198 millions of miles; Medusa makes its circuit in the shortest time, 3 years and 40 days. Thule (279) has the greatest mean distance, 4.26 times the Earth's distance from the Sun, or about 400 millions of miles; it has a period of nearly nine years. The average asteroid is 246 millions of miles from the Sun, and revolves about it in 4⅓ years. The inclinations of the orbit planes to the ecliptic average about 8 degrees, one degree more than the inclination of Mercury's orbit to the ecliptic, but Pallas (2), as we have previously remarked, has an inclination of 35 degrees and Euphrosyne (31), of 26½ degrees.

Several of the orbits are very eccentric; Aethra (132) has almost a cometary eccentricity of 0.34. A dozen others have eccentricities of about 0.30. These furnish a connecting link between comets and planets. In the case of Aethra its greatest distance is twice its least distance from the Sun: 312 millions and 156 millions of miles.

"The complexity of the interwoven orbits has grown almost in the numerical proportion of discovery." "Yet no two intersect, because no two lie exactly in the same plane, so that the chances of collision are at present *nil*. There is only one case, indeed, in which it seems to be eventually possible. M. Lespiault has pointed out that the curves traversed by Fides and Maia approach so closely, that a time may arrive when the bodies in question will either coalesce or unite to form a binary system." The breadth of the zone in which the minor planets travel is about 275 millions of miles. They go out dangerously near Jupiter and reach inward to Mars. The powerful attractions of these bod-

ies, especially Jupiter, perturb the little planets very greatly and make the calculations in regard to their orbits and positions extremely difficult. This labor has been carried on for years by a special bureau in Berlin. The trouble is so great that some astronomers have suggested that all but the most important be allowed to lose themselves; but the scientific sentiment is against such a policy. The future ought to behold a plan whereby the enlightened nations will join hands in dividing up the labor. These are the days of international agreement and enterprise in all things, and surely science should share in the great benefits to be certainly derived from international coöperation.

There are gaps in the zones of the asteroids; these gaps appear to be at such distances as would make the planet circulating therein have a period commensurable with Jupiter's period. The result would be that Jupiter would get a frequent pull on such planets and eventually so disturb them that they would crowd into the adjacent region, where the disturbing influence would be less felt. The most remarkable gap seems to be between 3.27 and and 2.50, * where the mean motion is two and three times as great as Jupiter's. There is another marked gap between 3.50 and 3.99, a space of about 37 millions of miles in width, in which circulate only one or two known asteroids. This gap covers the spaces in which asteroids must move in order that three revolutions of Jupiter may correspond to five revolutions of the minor planets, four of Jupiter to seven of minor planets, five to eight, five to nine, and seven to eleven, etc.

That the law of commensurability of orbits has greatly influenced the present distribution of the asteroids, as suggested by Kirkwood, there seems to be no room for doubt. The recent investigations of the German astronomers show that as the number of the asteroids increases, this law exhibits itself more strikingly.

The very rapid augmentation in the number of minor planets indicates that there may be thousands or even millions in the zone; with more powerful telescopes and more sensitive plates we may hope to find many of these thousands. And perhaps the same agencies will discover asteroids between the orbits of all the planets. It may happen that some one will show that under the influence of Jupiter a parabolic comet may be trapped into becoming an asteroid, or an asteroid may be so powerfully affected as to be compelled to move so close to the Sun as to become comet-like in appearance and orbit.

* The earth's distance from the Sun being represented by I.

As to the origin of the asteroids, present opinion furnishes three theories: "One is: that the material which according to the nebular hypothesis ought to have been concentrated to form a single planet of the class to which the Earth belongs, has failed to be so collected, and has formed a flock of small separate masses. It is now generally believed that the matter which at present forms planets was once distributed in rings like those of Saturn. If so, this ring next outside of Mars would necessarily suffer violent perturbations from the nearness of the enormous planet Jupiter, and so would be under very different conditions from any of the other rings. This, as Prof. Peirce has shown, might account for its breaking up into many fragments. A second view is that a planet about the size of Mars has broken into pieces. It is true, as has been often urged, that this theory in its original form, as presented by Olbers, cannot be correct. No single explosion of a planet could give rise to the present assemblage of orbits, nor is it possible that even the perturbations of Jupiter could have converted a set of orbits originally all crossing at one point (the point of explosion) into the present tangle. The smaller orbits are so small that, however turned about, they lie wholly inside the larger orbits, and cannot be made to intersect them. If, however, we admit a *series* of explosions this difficulty is removed; and if we grant an explosion at all there seems to be nothing improbable in the hypothesis that the fragments formed by the bursting of the parent mass would carry away within themselves the same forces and reactions which caused the original bursting, so that they themselves would be likely to explode at some time in their later history."

Kirkwood has suggested the third theory, the same cause which separated the head of a comet into several pieces, viz.: The unequal tidal action on the different parts of the comet by the Sun's attraction, may in the distant past have acted to divide the tenuous primitive masses. These tenuous masses of nebular matter were left behind by the contracting Sun, and later his tidal influence was so powerful as to break several of the masses into pieces. Kirkwood, Tisserand and the German astronomers have found weighty evidence in favor of this view. It would seem proper, however, to consider that we might apply all three theories at once; the facts rather favor such a combination.

"At the beginning of the 19th century this new field of research was opened to astronomers. A class of bodies till then unseen by the human eye and unimagined by the human brain; a class, indefinite in number, perhaps more difficult to enumerate than the

stars as seen without a telescope; a celestial cluster, in short, within our own solar domain was first revealed to telescopic view."

What do these asteroids indicate in regard to the physical history of planets or the laws by which the heavenly bodies are controlled? If "the universe is a book written for man's reading," only patient study may resolve the problem contained in these mysterious leaves.

NEW ELEMENTS, NEON AND METARGON.

By means of liquid air and other methods of producing extremely low temperature, Professor Ramsay and Dr. Norman Collie succeeded in liquefying a quantity of argon. It formed a colorless fluid, but two other products also resulted. These were a lighter gas, which failed to liquefy and was drawn off for further examination, and also a solid deposit which gathered on the sides of the tube. The light gas was first examined. Its spectrum was characterized by a number of bright red lines, one being particularly brilliant, and a yellow one of similar intensity. Green and blue lines were numerous, but inconspicuous. The yellow line is as intense as those in sodium, helium, and crypton, but is not identical with them.

Next, an effort was made to ascertain the density of the gas. The results of their experiment led the investigators to the conclusion that they had not as yet obtained it in a perfectly pure condition. A sample, taken off at an early stage, gave a density of 17.2; at a later one, however, it was reduced to 14.67. But this is still too high, if the new gas conforms to the periodic law, for in that case it should not exceed eleven. It may, however, be lowered by further purification. But these tests, and sundry others, suggest that, even if not yet obtained in an absolutely pure condition, this gas is a new element, for which, accordingly, the name neon is proposed.

They next turned their attention to the solid—the material frozen out of argon. Its spectrum proved to be very complex, but totally different from that of argon, and its behavior at low temperatures was markedly different, though its density was practically identical. It was proved to consist of a single element. This substance accordingly, which was separated by freezing out of argon, must be a distinct elementary body, though in some respects in close relation with it, so they propose to name it

metargon. In fact, as the investigators observe, it occupies the same position in regard to argon that nickel does to cobalt, having the same atomic weight, yet different properties.—*Journal of Chemistry.*

THE GROWTH OF WORLDS. I.

WM. W. PAYNE.

Our knowledge of the growth of worlds has come mainly from three sources: The men who have studied the heavens, the instruments they have used, and the records of work they have made. The order of progress in this knowledge has been: men, instruments, facts, theories and laws.

To get a clear idea how the knowledge of astronomy has *grown* into the oldest, the grandest and the most perfect of the sciences of to-day, we must think of the *men* who have worked hard and long to understand the mystery of the sky. We should know something of the *instruments* they have devised to help them in watching the stars, something of the *facts* they have learned, the theories formed, and finally the laws which govern the stuff that worlds are made of.

From early time, men have thought of the objects in the heavens in six classes. The Moon, the Sun, the planets, comets, the stars and the nebulae. Each one of these classes of the heavenly bodies has given something of its own, not found in others, to help in understanding how the universe is made. Not one of them could be spared from the list without taking away a source of much useful knowledge. Later on we will see how each kind of celestial object has given its own necessary part of truth and fact to build up a system of worlds into a great universe.

In a brief article, or even a series of them we can not go back in time to the dawn of astronomy and sketch the whole history, for that would mean a long period of time and require space not at our command.

So we must pass by the thoughts of devout men who built temples of worship in India and the pyramids of Egypt, that they might worship the Sun, the Moon and the stars according to the will of the gods. We must pass by much of the beauty of the heavens hinted at in the Bible, and much of the deep meaning of the *words* in ancient languages, the men of old used in naming the stars and the constellations which we now see.

It will serve our purpose best to begin with those great men who studied astronomy about the beginning of the Christian Era. Then Hipparchus should be first. He lived 160 years before Christ, and worked in the island of Rhodes, in the Grecian Archepeligo. He is rightly called the "father of astronomy" because he studied it in an orderly way. If Pliny is right, Hipparchus was led to the study of astronomy by seeing a new star near the Milky Way. He thought a catalogue of the stars should be made and began the work. His catalogue was the first, and it consisted of 1080 stars, all that could be well seen with the naked eye in his latitude. He measured the stars from the ecliptic and from the equinox.

In this study *Hipparchus* soon discovered that the equinoxes were not fixed points in the sky, but that they were moving backward or westward in reference to the fixed stars which will easily be understood by our readers without illustration. This would cause the *pole* of the equator to make a complete circuit among the stars around the pole of the ecliptic in 12,800 years. He was very nearly right in the value of this long period.

Hipparchus also had a way of explaining the motions of the planets by circles and epicycles which lived after him for a 1000 years.

In order to get the true places of the stars of his catalogue, Hipparchus would have to know trigonometry, plane and spherical; but there was no such branch of mathematics at this time and so he was obliged to invent a trigonometry, and he was equal to this hard task, so now we give him the credit of this useful piece of work both for mathematics and astronomy.

The next great man in the study of astronomy to be noticed is Ptolemy, who lived 300 years later, 140 A. D. near Alexandria in Egypt.

His chief astronomical instrument was a cross-staff and it was one of the most useful aids in the study of the heavenly bodies known to men of these times. If the staff is placed upright, and the observer sights from the end of the cross-arm, the figures on the upright part, will roughly measure the angle of the body above the horizon; so, places of the stars as related to the horizon can be known. Ptolemy had a wonderful record, as a man of science for his time. He knew how the refraction of the air affects the places of the stars. He knew some of the irregularities of the Moon's motion. He published a book on astronomy that was held as authority for 1400 years. In this book was given his plan of the solar system, which was the same as that of Hipparchus, except that it was worked out more fully.

In Young's General Astronomy paragraphs 500 and the following give the reader a general idea of the Ptolemaic System. For a more extended statement of it and the reasons for it, reference is made to page 8 of "Great Astronomers" by Sir Robert S. Ball, published by the J. B. Lippincott Company, Philadelphia, 1895. From facts given in these and other similar references, it seems evident that Ptolemy was as nearly right in his views as he certainly could be without better means of observation than those that were known to any astronomer in his day. His views of the movements of the planets were wrong in some respects, yet, his theory so well fitted the best knowledge of his time, that no one could say he was wrong, but on the contrary most people believed he was right, and even now some are found who still believe in the Ptolemaic System. The man's power evidently lay in the genius of his thought. He had a reason for things he believed and he could state his views in a way to carry conviction, for he had mastered the philosophy of his time, and his skill in mathematics was of the highest order. If the planets moved in curved orbits, their paths should be circles, because the circle was the most perfect plane figure known to the ancient geometer, therefore the heavenly bodies could not move in other paths than the circle.

Ptolemy believed that the Earth is globular in form, but he did not believe that it rotated on its axis daily as we now know it does.

His proofs for its globular form were the same as we now have, and the statement of them has not been much improved even to this day. But the rotation of the Earth on its axis was a fact that he could not prove, and he frankly said that the reasons against it to his mind were stronger than those offered in its favor. One instance of his thinking will show how he reasoned. If the Earth should turn on its axis, he said there is nothing to cause the air to turn with it, and such swift motion as the Earth must have to make one complete turn in twenty-four hours would cause fierce winds that would sweep everything from the Earth's surface. He did not think the atmosphere would be at rest if the Earth had the motion of rotation, but that it would lag behind somewhat, and yet he believed its movement in the opposite direction to that of the Earth might be ten times as great as the flight of a carrier pigeon. This is but a specimen of his thinking; other examples might be given, but they are not needed, for our present purpose.

One important view held by Ptolemy ought to be given in this

place. That is his reason for not thinking the Earth is flat like a plane. He said if it were like a plane, then the Sun would set for all people everywhere on it at the same time, and the Sun would rise for all people in the same way. This he knew was not true. There are a few people yet in almost every enlightened community who honestly think that the entire surface of this great Earth is as flat as the floor of a house. In Northfield, under the shadow of Carleton College, such a belief is held by some, otherwise intelligent citizens. Professor Richard A. Proctor, the astronomer, while editor of "Knowledge" used to name such people "Earth flatteners" in hearty disgust.

Ptolemy had a nearly true idea of the realitive size of the Earth. He knew that the stars were many, many times farther away than the distance that measured the diameter of the Earth. He knew the heavenly bodies did not change in size as they shifted from east to west at times of rising and setting. Hence, why should he not think that the Earth was at the center of the universe, and, from the appearance of all things terrestrial, believe that it was fixed and motionless in space.

Having made up his mind as to the fixity of the Earth in space, Ptolemy's other views related to this fact were largely decided by it; so he rejected the idea that the Earth could have a forward motion in space, for that fact could be proved in the same way as the motion of rotation which he thought he had shown to be impossible.

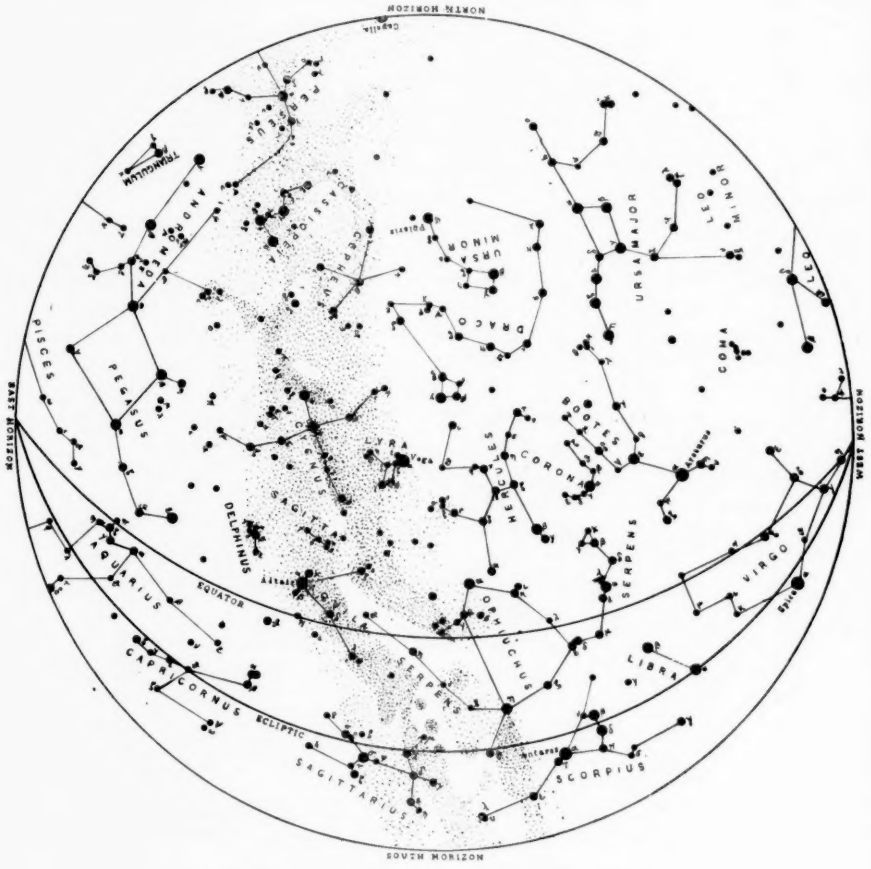
In regard to the stars, Ptolemy thought they were all the same distance from the Earth as a center, and that they were bright points fixed on the inner surface of a great sphere, and in keeping with this idea, early pictures representing the solar system, or any other system of the planets, will have around them a border of stars, in a circle signifying the limits of the stellar universe.

We wish to say more about the great men that worked in early times, laying the sure foundation for the science of astronomy that we enjoy so much, and use so profitably in modern times. If we are successful in securing good cuts of these noble men, we are sure that the brief accounts of their labors will be enlivened somewhat by a look at their earnest and thoughtful faces as we read of the glorious victories which they won for science so long ago.

PLANET NOTES FOR AUGUST.

H. C. WILSON.

Mercury will be at greatest eastern elongation, 27° 25′ east from the Sun, August 8 and will be visible to the naked eye for a few days or either side of that date. One must look for it near the west point of the horizon about an hour after sunset.



THE CONSTELLATIONS AT 9 P. M., AUGUST 1, 1898.

Venus is getting near greatest eastern elongation and approaching the Earth rapidly. The gibbous phase of her disc diminishes during August from 0.71 to 0.59, while her brightness increases in the proportion of 85 to 115. As this

month will be exceptionally favorable to the study of the surface markings of Venus, both in daylight and at night, it is to be hoped that the opportunity will not be neglected by those who have the use of telescopes of good defining power, and that the vexed question of those "straight-line" markings may be placed beyond dispute. We know that for some time past Professor Barnard has been systematically studying the planet with the 40-inch Yerkes telescope and that at the Lowell Observatory at Flagstaff, Ariz., more than one observer is thus employed. This should not prevent others from taking up the study, for the results so far obtained are discrepant, and telescopes of 10, 8 or even 6 inches aperture are liable to be just as effective as larger ones in the study of this planet.

Mars is morning planet, coming to the meridian at about half past seven. He begins the month directly north of the red star Aldebaran in Taurus and moves eastward to the border of Gemini. The apparent diameter of the planet is small, increasing from 6″ to 7″ during the month.

Jupiter has passed the best position for observation, but twilight views of the planet may yet be obtained. The most striking naked eye phenomenon to be predicted for the month is the conjunction of the two bright planets Jupiter and Venus, Aug. 18, at midnight by Central Standard Time. Venus will then be 1° 38′ south of Jupiter. During several nights the two planets will form a splendidly brilliant pair in the western sky.

Saturn is near the meridian at seven o'clock in the evening, just north of the bright group of stars in the Scorpion, contrasting well in its golden color with the ruddy hue of Antares. Saturn finishes his retrograde motion, becoming stationary Aug. 9, and then moves eastward. On Aug 28 Saturn will be at quadrature, 90° east from the Sun.

Uranus will be at the same quadrature Aug. 22, and is almost stationary a little way southwest of the star β in Scorpio.

Neptune will be in conjunction with Mars Aug. 24 at 8 P. M., and will then be 1° 11′ south of Mars in the southeastern corner of Taurus.

The Moon.

		Phases.	Rises. (Central Standard time at Northfield; Local Time 13m less)			Sets.		
			h	m		h	m	
Aug.	1	Full Moon	7	19	P. M.	5	32	A. M.
	8	Last Quarter	10	19	"	1	59	P. M.
	17	New Moon	5	33	A. M.	7	7	"
	24	First Quarter	1	40	P. M.	10	23	"
	31	Full Moon	6	38	"	6	59	A. M.

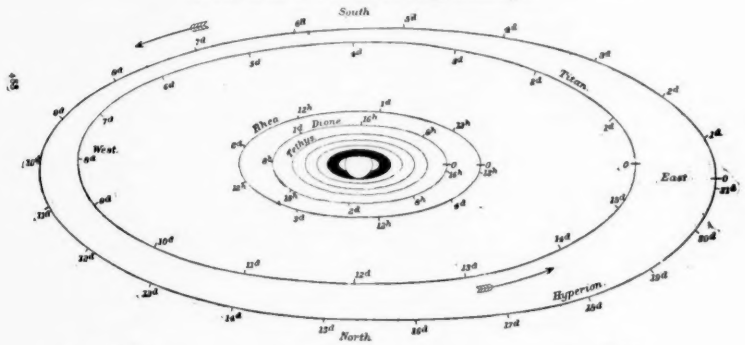
Occultations Visible at Washington.

Date 1898.		Star's Name.	Magnitude.	IMMERSION. Washington M. T. h	m	Angle from N pt. °	EMERSION. Washington M. T. h	m	Angle from N pt. °	Duration. h	m
Aug.	2	λ Capricorni	5 7	8	36	128	9	7	183	0	31
	2	B.A.C. 7620	6.5	12	50	105	13	38	184	0	48
	4	16 Piscium	5 8	11	47	9	12	35	283	0	48
	5	45 Piscium	6 9	10	59	33	11	58	264	0	59
	8	ε Arietis	4.6	12	45	5	13	15	308	0	30
	9	B.A.C. 1170	6.3	11	12	55	12	3	273	0	51
	13	63 Geminorum	5 7	16	37	110	17	45	264	1	8
	25	A Ophiuchi	4.9	8	21	134	9	12	216	0	51
	25	B.A.C. 5813	6 8	8	45	123	9	43	224	0	58
	28	σ Capricorni	5 6	5	52	56	6	58	271	1	6
	28	π Capricorni	5.1	10	44	29	11	47	273	1	3
	28	B.A.C. 7044	7.0	12	6	359	12	39	303	0	33
	30	θ Aquarii	4.4	8	24	77	9	32	221	1	8

Saturn's Satellites.

[The diagram indicates the position of the outer satellites of Saturn at intervals of 1 day, after greatest eastern elongation. The ephemeris below gives the Central Standard times when the satellites will be at either eastern elongation (E) or western elongation (W), or, in the case of the outermost ones, inferior conjunction, south of the planet, (I) and superior conjunction, north of the planet, (S).]

APPARENT ORBITS OF THE SEVEN INNER SATELLITES OF SATURN, at opposition in 1898, as seen in an inverting telescope.



I. MIMAS.

Period $0^d\ 22^h.6$

	h		
Aug. 5	10.5	P. M.	W
6	9.1	"	W
7	7.7	"	W
8	6.3	"	W
13	10.7	"	E
14	9.4	"	E
15	8.0	"	E
16	6.6	"	E
22	9.6	"	W
23	8.2	"	W
24	6 9	"	W
31	8.6	"	E

II. ENCELADUS.

Period $1^d\ 8^h.9$

	h		
Aug. 2	6.9	A. M.	E
3	3.8	P. M.	E
5	12 7	A. M.	E
6	9.6	"	E
7	6.5	P M.	E
9	3.4	A. M.	E
10	12.3	P. M.	E
11	9.1	"	E
13	6.0	A. M.	E
14	2.9	P. M.	E
15	11.8	"	E
17	8.7	A. M.	E
18	5.6	P. M.	E
20	2.5	A. M.	E
21	11.4	"	E
22	8.3	P. M.	E
24	5.1	A. M.	E
25	2.0	P. M.	E
26	10 9	"	E
28	7.8	A. M.	E
29	4.7	P. M.	E
31	1.6	A. M.	E

III. TETHYS.

Period $1^d\ 21^h.3$

	h		
Aug. 2	7.1	P. M.	E
4	4 4	"	E
6	1.7	"	E
8	11.0	A. M.	E
10	8 3	"	E
12	5 6	"	E
14	2 9	"	E
16	12 3	"	E
17	9.6	P. M.	E
19	6.9	"	E
21	4 2	"	E
23	1.5	"	E
25	10.9	A. M.	E
27	8.2	"	E
29	5.5	"	E
31	2.8	"	E

IV. DIONE.

Period $2^d\ 17^h.7$

	h		
Aug. 2	2.7	A. M.	E
4	8.3	P M.	E
7	2.0	"	E
10	7.7	A. M.	E
13	1 4	"	E
15	7.1	P. M.	E
18	12.8	"	E
21	6.5	A. M.	E
24	12 2	"	E
26	5.9	P. M.	E
29	11.6	A. M.	E
Sept. 1	5.3	"	E

V. RHEA.

Period $4^d\ 12^h.5$

	h		
Aug. 1	5.1	P. M.	E
6	5.6	A. M.	E
10	6.0	P. M.	E
15	6 5	A. M.	E
19	6.9	P. M.	E
24	7.4	A. M.	E
28	7 8	P. M.	E

VI. TITAN.

Period $15^d\ 23^h.3$

	h		
Aug. 2	11	P. M.	W
6	10	"	S
10	7	"	E
14	7	"	I
18	10	"	W
22	9	"	S
26	6	"	E
30	6	"	I

VII. HYPERION.

Period $21^d\ 7^h.6$

d		d	
Aug. 5.6	W	Aug. 22.1	I
10.9	S	27.0	W
16 8	E		

VIII. JAPETUS.

Period $79^d\ 22^h.1$

Aug. 2.7 S Sept. 10.2 I
22.0 E Oct. 1.0 W

VARIABLE STARS.

J. A. PARKHURST.

Maxima and Minima of Long Period Variables.

1898 October.

MAXIMA.

		m	day
22	Y Sculptoris	9	27
806	O Ceti (Mira)	3.5	6
906	R Trianguli	6.5	16
1018	R Horologii	6	21:
1113	U Arietis	8	18
1577	R Tauri	8	24
1717	V Tauri	9	13
1771	R Leporis	6.5	21
1803	T Leporis	8	20:
3637	S Carinae	6	24
3825	R Ursae Majoris	7	9
4492	Y Virginis	8.5	6
4511	T Ursae Majoris	7	20
4596	U Virginis	8	14
5237	R Bootis	7	24
5601	S Ursae minoris	7.5	4
5856	W Ophiuchi	9	4
5928	T Ophiuchi	10	23:
5955	R Draconis	7.5	12
6871	V Lyrae	9	22:
7155	RR Aquilae	8.5	22:
7192	Z Cygni	8	19
7242	S Aquilae	9	19

MAXIMA, CONT.

		m	day
8290	R Pegasi	7.5	9
8373	S Pegasi	7.5	30
8512	R Aquarii	7	17

MINIMA.

243	U Cassiopae	< 15	6
893	U Ceti	12	25:
1222	R Persei	13	22
1805	V Orionis	< 13	21:
1850	S Pictoris	< 13	—
3244	S Pyxidis	11	—
4521	R Virginis	10.5	15
5174	RS Virginis	12	—
5338	U Bootis	12.5	19
5675	V Coronae	11	31
5704	RR Librae	14	—
5887	V Ophiuchi	10	6:
5931	S Ophiuchi	< 13	—
7139	RR Sagittarii	< 12.5	3:
7444	T Delphini	< 13	—
7994	R Pisc. aust.	< 11	—

Minima of the Variable Stars of the Algol Type.

[Given to the nearest hour in Greenwich Mean Time.]

1898.

U CEPHEI.

	d	h
Sept.	3	7
	5	19
	8	7
	10	19
	15	18
	20	18
	25	18
	30	17

ALGOL.

	d	h
Sept.	3	21
	6	18
	9	15
	12	11
	15	8
	23	23
	26	20
	29	16

λ TAURI.

	d	h
Sept.	4	18
	8	17
	12	16
	16	14
	20	13
	24	12

R CANIS MAJORIS.

Every 8th min.

P = 1^d 3.3^h

	d	h
Sept.	1	13
	10	15
	19	17
	28	19

δ LIBRAE.

	d	h
Sept.	22	8
	29	8

U CORONÆ.

	d	h
Sept.	12	9
	19	6
	29	15

U OPHIUCHI.

Every 10th min.

P = 20^h.1

Sept.	3	4
	11	13
	19	23
	28	8

RS SAGITTARII.

	d	h
Sept.	4	13
	9	9
	16	15
	21	11
	28	16

W DELPHINI.

	d	h
Sept.	2	11
	7	6
	16	21
	21	17
	26	12

Y CYGNI.

Even min.

Sept.	2	9

Odd min.

Sept.	3	13

Y CYGNI. The minima are now visible to good advantage only in European longitudes. The first minimum of each class is given above. The others follow every third evening about five minutes earlier.

The authorities for the above ephemeris are the same as in the previous numbers of this volume.

NOTES.

MIRA. Rev. Walter Sidgreaves, of Stonyhurst College Observatory, has a finely illustrated article on the spectrum of Mira in the April number of the Monthly Notices. He secured 20 photographs of the spectrum between 1897 Nov. 18 and 1898 Feb. 5. (The maximum occured about Dec. 1.) A carefully drawn map is given of the lines in the spectrum, between wave lengths 4050 and 5850, accompanied by a catalogue of the wave lengths and intensities of the lines. The author notes the "extraordinary brilliancy of the hydrogen lines $H\delta$ and $H\gamma$ in the star's spectrum," and remarks "It seems more probable that o Ceti shows a condition of hydrogen radiance not yet met with in the laboratory, in which $H\alpha$ and $B\beta$ have fallen out of the spectrum."

Different observers have disagreed as to the constancy or variation of the redness of the light of Mira in its different phases. The photographs given in this article bear valuable testimony on this question. The author remarks "The spectrum has apparently remained substantially constant during the period of observation. But a marked change in the relative intensities of the yellow-green and the blue radiations appears to have taken place during the cloudy week between December 2 and December 11. On all the preceeding dates the photographs show the maximum silver deposit in the blue region of the spectrum; and on all the subsequent dates the yellow-green radiation has produced the stronger impression."

MR. W. E. SPERRA, well known to readers of this magazine for his work with variable stars, has enlisted in the army and is a member of Light Battery F, 4th Artillery, probably at this writing before Santiago. He wrote last from Port Tampa, June 28, and was then under orders to move at a moment's notice, with transports waiting. We wish him safety and success.

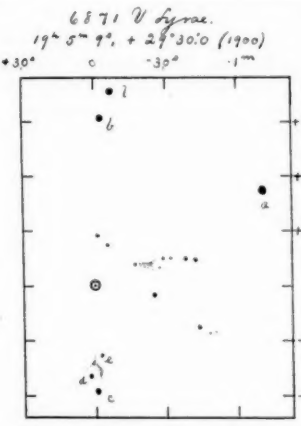
OBSERVATIONS WITH THE YERKES 12-INCH REFRACTOR. This instrument is being used on some of the fainter variables, especially those whose minimum maguitude is unknown. The following notes may be of interest.

ANDERSON'S VARIABLE 2376 S LYNCIS. (See pages 118 and 185 of this volume of POPULAR ASTRONOMY). This new variable has passed its minimum in very unfavorable position for observation. It has been fainter than the close companion noted on page 185, since April 1. It is now about half a magnitude brighter than the companion, therefore about $12^m.0$ or $12^m.2$. Further observations will be necessary to determine the time of minimum, but the magnitude at that phase can be placed at decidedly below 13 and probably as faint as 14.

5830 R SCORPII. (See *P. A.* Vol. IV, pages 275 and 331). No minimum of this interesting variable was on record at the time of the publication of Chandler's Third Catalogue. It is only known that the magnitude at minimum is less than 13. At this writing it is invisible in the 12-inch, and therefore less than 14^m. The minimum is expected sometime in July.

6100 RV HERCULIS. This star has passed a faint minimum and is now about 15^m and brightening. (See Vol. V, page 326).

6871 V LYRÆ. In the Third Catalogue the minimum magnitude of this star is placed at 12. It certainly goes below the 14th magnitude as it is now invisible



Yerkes Observatory, 1898 July 11.

in the 12-inch. The accompanying small chart will help to identify the variable, the stars *a*, *b*, *c*, *d* and *l*, are *D.M.* stars ranging from 8 to 9^m.5. The faintest star shown near the variable is about 13^m.

6899 U DRACONIS. (See *P. A.* V, page 556). This new variable has lately passed a minimum near the 13th magnitude. Its high northern declination and its nearness to the 3d magnitude star δ Draconis render it especially available for observation.

THE NEW VARIABLE IN CASSIOPEÆ, charted on page 118 of this volume, since March has faded from 9.5 to less than the 12th magnitude. It is also readily found without circles. (R. A. 23^h 55^m 53^s, Decl. + 54° 52′.3, for 1855, and 40′ following *sigma* Cassiopeæ).

COMET NOTES.

Ephemeris of Perrine's Comet *b* 1898.—This comet is becoming very faint but may still be followed with large telescopes. In *Astronomische Nachrichten*, No. 3504, Mr. S. K. Winther, of Copenhagen, gives an ephemeris extending from July 16 to Oct. 1. The following is the portion for August:

	α			δ			log *r*	log △	Brightness.
	h	m	s	°	′	″			
Aug. 1	5	56	41	+ 52	41	5			
2	5	58	10	+ 52	37	15	0.3684	0.4589	0.07
3	5	59	36	+ 52	33	29			
4	6	1	0	+ 52	29	46			
5		2	23	+ 52	26	6			
6		3	44	+ 52	22	31	0.3769	0.4607	0.06
7		5	4	+ 52	18	59			
8		6	21	+ 52	15	31			
9		7	37	+ 52	12	6			
10		8	51	+ 52	8	45	0.3853	0.4621	0.06
11		10	4	+ 52	5	29			
12		11	15	+ 52	2	17			
13		12	23	+ 51	59	8			
14		13	30	+ 51	56	4	0.3934	0.4628	0.06
15		14	35	+ 51	53	4			
16		15	38	+ 51	50	8			
17		16	40	+ 51	47	17			
18		17	40	+ 51	44	29	0.4015	0.4635	0.06
19		18	38	+ 51	41	46			
20		19	34	+ 51	39	7			
21		20	29	+ 51	36	32			
22		21	22	+ 51	34	2	0.4093	0.4636	0.05
23		22	13	+ 51	31	36			
24		23	2	+ 51	29	14			
25		23	50	+ 51	26	56			
26		24	35	+ 51	24	43	0.4170	0.4632	0.05
27		25	19	+ 51	22	34			
28		26	1	+ 51	20	29			
29		26	42	+ 51	18	29			
30		27	21	+ 51	16	32	0.4245	0.4625	0.05
31	6	27	57	+ 51	14	40			

Comet *c* 1898 (Coddington-Pauly).—"This comet was discovered by Mr. Coddington at Lick Observatory June 11, 1898, on a photographic plate taken by him with the Crocker photographic telescope on the evening of June 9, 1898. Owing to changes that were being made in his dark room this plate was not developed until June 11. On developing the plate a strong trail was found. The region was at once examined with the 12-inch telescope, and an observation of the comet made by Professor Hussey." The comet was independently discovered on June 14 by Mr. W. Pauly, at Bukarest, with a three inch telescope. The comet was bright enough to be easily seen with such an instrument, having a central condensation as bright as an 8 magnitude star with a coma 2′ or 3′ in diameter and a short brush of tail. It is now too far south for northern observers to reach it.

EPHEMERIS OF COMET *c* 1898.

	α			δ			log *r*	log Δ
	h	m	s	°	′			
Aug. 2	13	55	45	− 47	52.6		0.2514	0.1461
6		50	20	− 48	56.7		0.2475	0.1591
10		45	48	− 49	59.9		0.2439	0.1716
14		42	7	− 51	3.1		0.2406	0.1835
18		39	14	− 52	6.9		0.2377	0.1948
22		37	4	− 53	11.8		0.2352	0.2054
26		35	34	− 54	18.3		0.2330	0.2154
30	13	34	42	− 55	26.6		0.2312	0.2246

Elements and Ephemeris of Comet *c*, 1898 (Perrine.)—From my observations of June 17, 24 and July 1, I have obtained the following system of parabolic elements,

T	1898 August 16.23874 Gr. M. T.			
ω	205°	12′	18″.2	Ecliptic and Mean Equinox of 1898.0
Ω	259	10	16 .4	
i	70	0	10 .8	
log q	9.800186			

Residuals for the middle place, observed—computed:

$\Delta\lambda' \cos\beta$	− 2″.5
$\Delta\beta'$	+ 4 .0

CONSTANTS FOR THE EQUATOR OF 1898.0.

$x = r\,[9.585297] \sin(175° \;\; 59′ \;\; 4″.8 + v)$
$y = r\,[9\;999854] \sin(\;\;89 \;\; 32 \;\; 31 \;\; .0 + v)$
$z = r\,[9\;965361] \sin(180 \;\; 9 \;\; 29 \;\; .9 + v)$

EPHEMERIS FOR GREENWICH MEAN MIDNIGHT.

1898		True α			True δ		log *r*	log Δ	Br.
		h	m	s	°	′			
July	8.5	5	41	27	+ 48	48.6	0.0070	0.2364	2.45
	10.5	5	50	56	47	29.0			
	12.5	6	0	9	46	4.8	9.9811	0.2274	2.88
	14.5		9	6	44	36.0			
	16.5		17	48	43	2.5	9.9544	0.2184	3.39
	18.5		26	15	41	24.3			
	20.5		34	30	39	41.4	9.9271	0.2094	4.01
	22.5		42	33	37	53.8			
	24.5		50	25	36	1.1	9.8998	0.2007	4.74
	26.5	6	58	9	34	3.7			
	28.5	7	5	45	32	1.6	9.8734	0.1921	5.56
	30.5		13	15	+ 29	54.6			

1898	True α h m s	True δ ° ′	log r	log Δ	Br.
Aug. 1.5	7 20 42	+ 27 42.7	9.8488	0.1839	6.47
3.5	28 8	25 26.1			
5.5	35 33	23 5.0	9.8275	0.1762	7.39
7.5	43 0	20 39.8			
9.5	50 31	18 10.8	9.8114	0.1692	8.22
11.5	7 58 7	15 38.0			
13.5	8 5 50	13 2.1	9.8021	0.1631	8.83
15.5	13 43	10 23.4			
17.5	21 45	7 43.0	9.8006	0.1584	9.08
19.5	29 58	5 1.7			
21.5	38 21	+ 2 20.2	9.8071	0.1554	8.94
23.5	46 56	− 0 21.0			
25.5	8 55 44	3 1.0	9.8209	0.1546	8.42
27.5	9 4 44	5 38.8			
29.5	13 56	8 13.9	9.8404	0.1564	7.63
31.5	23 18	10 45.4			
Sept. 2.5	32 51	13 12.8	9.8640	0.1607	6.71
4.5	42 34	15 35.2			
6.5	9 52 26	17 52.4	9.8899	0.1678	5.76
8.5	10 2 26	20 3.9			
10.5	12 32	22 9.4	9.9170	0.1773	4.87
12.5	22 43	24 8.4			
14.5	32 58	26 1.0	9.9443	0.1890	4.07
16.5	43 16	27 47.2			
18.5	10 53 36	29 27.0	9.9713	0.2024	3.38
20.5	11 3 55	31 0.3			
22.5	14 13	32 27.4	9.9975	0.2171	2.80
24.5	24 29	33 48.3			
26.5	34 41	35 3.3	0.0228	0.2327	2.32
28.5	44 49	36 12.6			
30.5	11 54 50	37 16.5	0.0470	0.2489	1.93
Oct. 2.5	12 4 46	38 15.3			
4.5	12 14 32	− 39 9.3	0.0701	0.2654	1.60

The unit of brightness is that at discovery.

The comet is much brighter and a nucleus of about the 12th magnitude has developed. C. D. PERRINE.

MOUNT HAMILTON, California,
1898, June 11.

Perrine's Comet *e* 1898 and the Pons-Brooks Comet 1884 I.—Dr. Schorr calls attention to the striking similarity of the orbit of the comet discovered by Perrine June 14, 1898, to that of the periodic comet Pons-Brooks which was observed at its last return in 1884. The following approximate elements placed side by side render the similarity very apparent:

ELEMENTS.

	Pons-Brooks Comet.	Perrine's Comet *e* 1898.
ω	199° 12′	205° 12′
Ω	254 6	259 10
i	74 3	70 0
log q	9.8897	9.8002

The Pons-Brooks comet has a period of 71 years while Perrine's comet as yet shows no signs of deviation from a parabolic orbit, so it is doubtful whether they even belong to the same family.

Comet *g* 1898 (Giacobini).—This comet was discovered by Giacobini at Nice, France, on June 18. The telegram announcing the discovery, owing to an

unusual address, did not get to the hands of Mr. John Ritchie, Jr., who distributes such news to American astronomers, until after several days. Astronomers were somewhat puzzled at receiving data of an observation on June 19 of a comet whose discovery had not been announced. The only observations thus far published are the following:

	Local M. T.		Place.	App. α			App. δ			Observer
	h	m		h	m	s	°	′	″	
June 18	13	0	Nice	20	36	28	−21	14		Giacobini
19	12	40.6	"	20	26	40.8	−21	27	6	Javelle
20	11	59.1	Strassburg	20	15	23.5	−21	44	29	Kobold
21	11	59.7	Munich	20	3	2.4	−22	0	28	Villiger
21	12	40.2	"	20	2	41.0	−22	0	53	Villiger
21	13	19.3	Bamberg	20	2	18.7	−22	1	3	Hartwig

The only elements that have reached us are by Dr. H. Kreutz from the observations June 19, 20 and 21.

T = July 6.238, 1898, Berlin Mean Time.

ω = 7° 36′.4
Ω = 278° 31′.0
i = 166° 44′.8
$\log q$ = 0.20042.

The ephemeris extends only to July 15 and it would be useless to extend it further without better elements.

Ephemeris of Wolf's Periodic Comet.

[From *Astr. Nach.* No. 3481].

	α			δ		$\log r$	$\log \Delta$	Brightness.
	h	m	s	°	′			
Aug. 2	4	31	43	+ 18	2.6	0.2120	0.2659	2.38
6		42	28	+ 17	27.4	0.2141	0.2611	2.42
10	4	52	59	+ 16	48.8	0.2163	0.2562	2.44
14	5	3	13	+ 16	6.0	0.2188	0.2514	2.47
18		13	12	+ 15	19.6	0.2215	0.2466	2.49
22		22	52	+ 14	29.5	0.2245	0.2417	2.50
26		32	13	+ 13	35.7	0.2276	0.2368	2.53
30	5	41	13	+ 12	39.5	0.2309	0.2320	2.55

Encke's Comet is now too far to the south for observation in our latitude.

Comet *c* 1898 (Coddington).—An announcement of the discovery of this comet by means of photography was published in the *Pittsburg Times* of June 13, stating that it was "about one degree northeast of the bright star Antares," and "moving toward the southeast about one degree per day."

On June 13, $10^h\ 45^m$, 75th Meridian Time, I turned my four-inch refractor in the direction of Antares, and almost the first thing I saw was a beautiful comet in the field with the cluster *Messier* 4 (N. G. C. 6121). I estimated it to be 15′ or 16′ almost exactly south following the centre of the cluster, which gives the approximate position $\alpha = 16^h\ 18^m.4$; $\delta = -26°\ 28'$. It seemed probable that there was an error in the announcement, and that this was Coddington's comet; but, as its position did not agree with the published direction of motion, I was not sure that it was *not* a new one, and thought it best to announce it. Accordingly, I wrote to Dr. John A. Brashear, who has charge of the Allegheny Observatory, and he kindly informed me that the comet I observed was the one discovered by Coddington.

This comet was about equal in brightness to the cluster *Messier* 80, but was much larger, and was distinctly visible in the 1¼-inch finder as a small nebulous spot. It had a strong central condensation with something that looked very much like a stellar nucleus, but of this I was not quite sure, as it was difficult to see. At first sight it appeared perfectly round, without any tail, but careful scrutiny revealed a short extension of the coma on the northern side. I did not note any change in appearance or brightness between June 13 and 24.

I searched carefully for this comet on July 9 and 10, but owing to its nearness to the horizon, and the lack of an ephemeris, I was unable to find it.

In this connection I would suggest that a correct announcement of the discovery of each new comet should be given to the Associated Press as soon as possible, by those having the matter in charge. There is a large number of amateur astronomers that must rely almost entirely on the daily newspapers for prompt announcements, and they have often proved very untrustworthy. Out of five comets discovered during the month of June, I saw the announcement in the daily papers of the discovery of only *one*. I think that this condition of affairs could be changed if the proper persons would see that the announcements are regularly given out, as the newspapers are always anxious for news of this kind. Besides, the discovery of a new comet affords an opportunity for increasing popular interest in astronomy, and this should not be lightly thrown away.

Hawthorn, Penn'a., ZACCHEUS DANIEL.
1898 July 16.

GENERAL NOTES.

We have given large space to the paper by Professor William H. Pickering on the meteoric shower of Nov. 13, 1897, because the study of it may mean so much to those who would prepare for successful observation of the great shower of the Leonids expected in November, 1899.

We wish to ask of astronomers generally that they send us often brief accounts of astronomical work going on under their direction that the same may be promptly known by others interested. A very little time and attention of each, in this way, would yield large benefit to the many.

Next time we will publish a continuation of the list of astronomical telescopes which appeared in the July number, giving those of 13 and of 12 inches aperture as reported by the *Observatory* for July. We found a few errors in the previous list and corrected the same before publication as far we know. It is very desirable that the forthcoming list be correct, and attention is asked to it for this purpose when it appears. These lists are put in small type that they may be put on cards for easy reference.

The Van Duzee 16-inch Dialyte.—In your list of large refractors published in the July No. of POPULAR ASTRONOMY, there is an error which has run the rounds of such printed lists for nearly 50 years. Though of but little importance I think it best to correct it. I allude to the alleged 18-inch Vander Zee telescope. Its maker the late Henry Fritz, who also made my 4½-inch comet seeker, had he lived, would have become a distinguished telescope maker.

The telescope he made for Dr. Van Duzee (not Vander Zee) about 1855, was a dialyte of 16-inch aperture. He never did much with it, probably owing in a great measure to the style of the instrument which was never a success. He once gave me the place of a nebula he discovered with it, which last evening I tried to find, but soon became convinced that it was N. G. C. 6106, discovered by Sir William Herschel, April 13, 1784.

LOWELL OBSERVATORY, Echo Mountain, Cal., July 9, 1898. LEWIS SWIFT.

Vacation Notes.—On my vacation trip this summer I spent several pleasant days at the observatories of the Universities of Chicago and Cincinnati.

At Williams Bay as the guest of Professor Barnard, it was a delight to witness the workings of that new but already great institution, the Yerkes Observatory. The great telescope and its dome were of course the first objects of interest to an astronomer. Their immense weight would render them unmanageable by the means employed in small observatories, but the electric motors which are provided to move the dome, the telescope and the lifting floor in this case seem to work admirably. It was my hope to strike one of those rare nights, when the seeing is excellent in this region, and know from experience what the great 40-inch object glass would do on some familiar object, but I was doomed to disappointment, the atmosphere being very much disturbed during my whole stay. The telescope is in use all the time when the weather permits. Professor Hale is photographing systematically the spectra of the brighter stars of the Fourth Type and has already obtained some very valuable results. He is also experimenting upon a bolometric study of the solar corona, having as yet no certain results in this line. Professor Barnard is measuring the parallax of some of the nebulae, the diameters of the planets and the positions of their satellites. He has spent some time in triangulating the cluster Messier 5 and has verified the rapid variation in brightness of some of the stars in that cluster, which was discovered by the Harvard College observers from comparison of their photographs. The star camera donated by Miss Catharine Bruce is not yet completed.

Mr. Burnham whose time is occupied all the week in his capacity as clerk of the U. S. Circuit Court at Chicago, makes the journey of 75 miles to Williams Bay every Saturday afternoon in order to use the telescope in completing his great catalogue of double stars.

Not the least important part of the Observatory is the well equipped shop, occupying several rooms in the basement, where apparatus of almost any kind may be constructed. I saw there in course of construction, parts of the spectro-heliograph for the 40-inch telescope, an equatorial mounting for a reflecting telescope, a universal transit, and most interesting of all a 60-inch reflector in process of grinding by Mr. Ritchey. This reflector is of glass 8 inches thick and was first ground so that both faces were flat and parallel; then one surface was ground to a concave spherical curve. The polishing and silvering is yet to be completed. The grinding thus far has occupied about six months. The reflector is to be mounted as an equatorial *coudé* and used for spectroscopic work. The spectroscopic parts will be stationary and it is hoped that by prolonging the exposures from night to night, photographs of the spectra of stars may be obtained with the grating.

At Cincinnati Observatory we found Professor Porter occupying himself chiefly with the proper motions of stars, a new catalogue of which he expects to issue about the end of this year. In connection with the study of proper motions, Professor Porter does a considerable amount of meridian circle work, verifying by his own observations all cases of suspected motion. H. C. WILSON.

The Ages of the Stars (Letter of Dr. See to the Editor).—Some time ago you were kind enough to send me the second of Professor Schiaparelli's interesting papers entitled *Rubra Canicula*, and to ask for a review of the investigations of the distinguished Italian astronomer. It may not be known that M. Schiaparelli took up the question of the ancient color of Sirius without knowledge of my previous work; when his attention had been called to it by the editor of the *Astronomische Nachrichten*, he wrote and obtained a copy of the paper (*Astronomy and Astro-Physics*, April and May, 1892). In his first paper various authors are examined, and the conclusion reached that probably no change of color has taken place; in the second paper, he devotes attention to the argument adduced by me, but entirely passes over the evidence drawn from Ptolemy, and in this way reaches the conclusion that the question is still in doubt.

It is unfortunate that the decisive evidence of Ptolemy should be overlooked. For after the false criticism of Schellerup had misled astronomical opinion, I showed once for all that Ptolemy certainly classed Sirius as fiery red. As all other authorities confirm the classification given by Ptolemy, I concluded that a change of color had taken place. Hence while the recent discussion has increased the interest in the question of the ages of stars of different colors, it has not materially added to our knowledge of the subject.

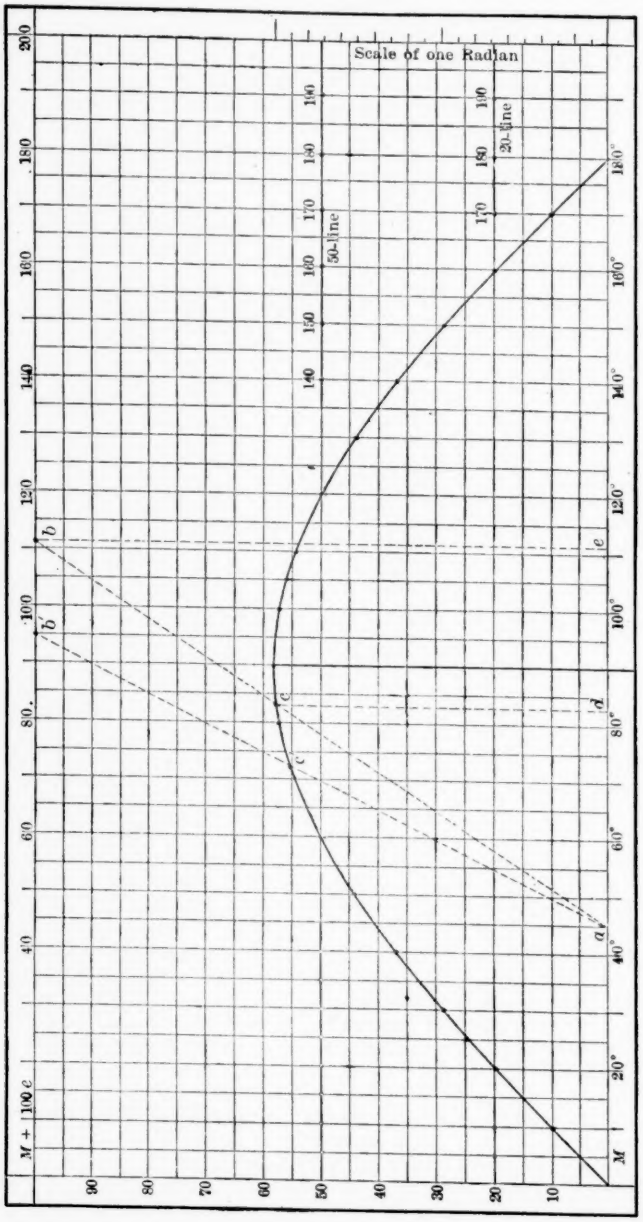
Some persons are unable or unwilling to believe a change of color has taken place, unless we are able to explain why and how it has happened. Others look upon a change of color with disfavor, because such an event would contradict current spectroscopic theories, which at best can claim only a doubtful validity. Some researches recently undertaken indicate that the spectroscopic theories which regard the Sirian stars as young and closely related to the nebulæ are entirely misleading. Indeed there are several grounds for rejecting their theories, and some of them are based upon the most fundamental principles known to physical science. As the work is not yet completed, I reserve for the present further comment on the views now universally current.

It is a somewhat singular fact that although many thousands of photographs of stellar spectra have been taken and the results classified according to certain arbitrary types, there is no proof that these types represent what is assumed; and until such proof can be furnished the conclusions now prevalent must be received with great mental reservation. Very truly yours,

T. J. J. SEE.

Graphical Solution for *u*.—An approximate value of u is obtained by the *curve of sines*, as shown in the accompanying figure. If from any point c on the curve a line be drawn at such a slope that $ad + cd$ equals the eccentricity of the orbit in question (*i. e.* if $\tan acd = e$), then $ad = e \times dc = e \sin (c)$, (c) being the angle indicated by the position of c and d (82½° in the case shown in the figure), and $Ma = (c) - e \times \sin (c)$, *i. e.* (c) *is the eccentric anomaly corresponding to the mean anomaly* Ma in an orbit having e for its eccentricity. To facilitate the construction of the inclined line at the proper slope, the upper horizontal line, marked $M + 100\ e$, is drawn at the distance of 100 units from the base line M, upon which the degrees are marked. To find the *eccentric anomaly* corresponding to a given *mean anomaly*, it is therefore only necessary to mark the point a, corresponding to the given mean anomaly (supposed to be 45° in the figure), and on the upper line the point b, corresponding to $M + 100\ e$, which is 111.1 in the illustration, the eccentricity being taken as 0.661 from the example given in the next article. Join a and b, and the point c gives the corresponding *eccentric*

GRAPHIC SOLUTION FOR u BY THE CURVE OF SINES.



From the New Edition of Professor Young's General Astronomy (now in press). By kindness of the author.

anomaly. (Generally it will be best to use a fine thread to join *a* and *b*, rather than to trust an ordinary ruler). Of course the joining line need not be actually drawn, as we want only its point of intersection with the curve. If the mean anomaly had been 90° instead of 45°, *b* would of course have been 156 1, the eccentricity remaining unchanged. If the ellipse had an eccentricity of 0.50 exactly, then for a *mean anomaly* of 45° the point on the upper line would be at 95 (*b'* in the figure) and then *u* would be at *c'*, *i. e.* 72¼°. When the mean anomaly exceeds 100°, it may be found impossible to lay off $M + 100\ e$ as directed. In that case $M + 50\ e$ may be laid off on the "*fifty*-line;" or, if *M* is near 180°, $M + 20\ e$, laid off on the "*twenty*-line," will answer the same purpose.

Owing to slight imperfections in the diagram, due to inaccuracies in the drawing, in the ruling of the squares, unequal shrinkage of the paper, etc., the values of *u* obtained from it are only approximate, but can generally be relied on to within about ¼°. This is near enough for many purposes (double-star orbits, for instance), and is always sufficient as the starting-point for a numerical calculation.

Stars Having Peculiar Spectra.—A list of stars having peculiar spectra is given in the annexed table. With one exception, noted below, they were all discovered by Mrs. Fleming in her regular examination of the Draper Memorial photographs. The designation of the star, its approximate right ascension and declination for 1900, its catalogue magnitude, and a brief description of its photographic spectrum are given in the successive columns of the table. When the object is not a catalogue star its position, as derived from a photograph, is given in the notes following the table.

Designation.	R.A. 1900		Decl. 1900.		Magn.	Description.
	h	m	°	′		
.....	0	54.2	− 75	32	...	Type III. Hydrogen lines bright. Variable.
+ 11° 305	2	9.6	+ 11	47	8.9	Type IV.
A.G.C. 4042	3	35.2	− 55	43	8.2	Type III. Hydrogen lines bright? Variable.
.....	4	52.0	− 67	6	...	Gaseous nebula. Gal. long 244° 36′, lat. — 36° 03′
Z. C. 5h 418	5	12.3	− 47	2	8.5	Type III. Hydrogen lines bright. Variable.
− 12° 1453	6	17.1	− 12	56	9.6	Gaseous nebula. Gal. long. 188° 54′, lat. — 11° 01′
− 12° 1500	6	23.7	− 12	59	7.7	Type I. *Hβ* bright.
+ 5° 1267	6	25.2	+ 5	57	7.1	Type I. *Hβ* bright.
− 8° 1467	6	28.1	− 8	48	8.5	Peculiar. Variable with small range.
+ 6° 1309	6	32.0	+ 6	14	6.5	Type I. *Hβ* bright. H. P. 1250.
.....	7	13.9	− 13	3	...	Type V. Gal. long. 195° 30′, lat. + 1° 11′.
− 3° 1873	7	18.1	− 4	0	9.2	Type IV.
− 11° 6941	7	22.4	− 11	31	8.9	Peculiar. Variable.
− 17° 2442	8	15.2	− 17	57	9.1	Type IV.
.....	9	6.1	− 69	32	...	Gaseous nebula. Gal. long. 253° 06′, lat. — 14° 50′
.....	9	13.5	− 65	49	...	Type IV. Variable.
+ 60° 1246	10	8.3	+ 60	31	6.3	Type III. Peculiar. Variable.
A.G.C. 14145	10	17.2	− 55	33	5	Type I. *Hβ* and *Hγ* bright. J Velorum.
A.G.C. 14686	10	40.1	− 59	1	7	Type I. *Hβ* bright.
.....	10	42.6	− 65	5	...	Type IV.
Z. C. 11h 129	11	2.9	− 54	35	9	Type IV.
.....	11	55.3	− 54	33	...	Type IV.
− 4° 3199	11	59.6	− 5	13	8.7	Type II. Variable.
.....	13	26.8	− 61	48	...	Type V. Gal. long 275° 30′, lat. — 0° 18′.
.....	13	29.1	− 61	45	...	Type V. Gal. long. 275° 46′, lat. — 0° 18′.
....	15	26.7	− 71	34	...	Type I. *Hβ*, *Hγ*, *Hδ*, *Hε*, and *Hζ* bright.
Z.C. 18h 1935	18	35.2	− 51	51	9	Type IV.
.....	19	47.0	− 65	37	...	Peculiar.
.....	21	36.6	− 65	30	...	Type IV.
− 8° 5858	22	16.5	− 8	7	8.5	Type III. Hydrogen lines bright? Variable.

$0^h\ 54^m.2$. Position for 1875, R. A. $= 0^h\ 53^m\ 22^s.4$, Decl. $= -75°\ 40'\ 30''$.

$4^h\ 52^m.0$. Position for 1875, R. A. $= 4^h\ 52^m\ 1^s.2$, Decl. $= -67°\ 7'\ 39''$. This object is N. G. C. 1714.

$7^h\ 13^m.9$. Position for 1855, R. A. $= 7^h\ 11^m\ 45^s.4$, Decl. $= -12°\ 58'\ 2''$.

$7^h\ 18^m.1$. In the *Astron. Nach.* Vol. 118, p. 259, Espin gives $-3°$ 1886, magn. 8.7, as having a spectrum of the fourth type. $-3°$ 1886 follows $-3°$ 1873 $1^m.8$ south $0'.3$, and has a spectrum of the first type. Probably $-3°$ 1873 was the object observed by Espin but erroneously identified by him.

$7^h\ 22^m.4$. The spectrum of this star resembles that of a star of the fourth type. The bands, however, are of shorter wave length, and are, perhaps, identical with those of a star of the third type. The portion of a spectrum whose wave length is less than $H\gamma$, 4341, is too faint to appear in the photographs.

$9^h\ 6^m.1$. Position for 1875, R. A. $= 9^h\ 5^m\ 50^s.3$, Decl. $= -69°\ 25'\ 58''$.

$9^h\ 13^m\ 5$. Position for 1875, R. A. $= 9^h\ 12^m\ 59^s.8$, Decl. $= -65°\ 42'\ 37''$.

$10^h\ 17^m.2$. The lines $H\beta$ and $H\gamma$ in this star have been found to be variable by Miss A. J. Cannon. On June 2, 1893, they were bright, and superposed on a broad dark band. On April 17, 1895, and March 17, 1896, these lines, like the other hydrogen lines, were dark.

$10^h\ 40^m.1$. The hydrogen lines in this star appear to be variable. On May 20, 1892, $H\beta$, $H\gamma$, and $H\delta$ were dark. On April 3, 1895, the line $H\beta$ was bright. On April 21, 1895, $H\beta$ and $H\gamma$ were bright. $H\zeta$ and $H\eta$ were dark, with the edge of greater wave length apparently bright.

$10^h\ 42^m.6$. Position for 1875, R. A. $= 10^h\ 41^m\ 40^s.8$, Decl. $= -64°\ 57'\ 20''$.

$11^h\ 55^m.3$. Position for 1875, R. A. $= 11^h\ 54^m\ 3^s.1$, Decl. $= -54°\ 25'\ 24''$.

$13^h\ 26^m.8$. Position for 1875, R. A. $= 13^h\ 25^m\ 6^s.2$, Decl. $= -61°\ 40'\ 30''$.

$13^h\ 29^m.1$. Position for 1875, R. A. $= 13^h\ 27^m\ 23^s.2$, Decl. $= -61°\ 37'\ 4''$.

$15^h\ 26^m.7$. Position for 1875, R. A. $= 15^h\ 24^m\ 8^s.2$, Decl. $= -71°\ 29'\ 26''$. This is the object whose position for 1900 is announced in ***Astronomy and Astrophysics***, Vol. 12, p. 546, as R. A. $= 15^h\ 27^m.0$, Decl. $-71°\ 32'$. Its spectrum is there described as of the third type having also bright hydrogen lines, and consequently it was suspected of variability. Later and better photographs show that the spectrum is continuos, with the hydrogen lines $H\beta$, $H\gamma$, $H\delta$, $H\varepsilon$, and $H\zeta$ bright, resembling that of η Carinæ as seen with the same dispersion. The variability is not confirmed.

$19^h\ 47^m.0$. Position for 1875, R. A. $= 19^h\ 44^m\ 37^s.0$, Decl. $= -65°\ 41'\ 9''$.

$21^h\ 36^m.6$. Position for 1875, R. A. $= 21^h\ 34^m\ 37^s.9$, Decl. $= -65°\ 37'\ 28''$.

Stars Resembling ζ Puppis.

Besides ζ Puppis, the additional lines due to hydrogen are present in the spectra of the first and second classes of stars of the fifth type (*Astron. Nach.* Vol. 127, p. 1) and in the spectra of the first group of stars of the Orion type according to the classification of Miss Maury (H. C. O. Annals, XXVIII, p. 15). The lines whose wave lengths are there given as 4200.3, 4542.7, are probably additional hydrogen lines, and the line 4685.4 probably coincides with the bright band in ζ Puppis. Miss A. J. Cannon, from a careful study of the Draper Memorial photographs of the bright southern stars, has added the following stars to those already known to contain these lines. In A. G. C. 17572 the lines 3925, 4027, 4202 and 4544 are present and dark. In the fifth type stars, A. G. C. 8631 and 22763, the lines 4027, 4202 and 4544, and the bands 4633 and 4688 are present and bright. In the fifth type stars, A. G. C. 10863, 22748 and 22843, the hydrogen lines 3925, 4027, 4202 and 4544 are present and dark, and the bands

4633 and 4688 are present and bright. The band 4633 is double in the last two stars, and also in A. G. C. 9311, 29 Canis Majoris. EDWARD C. PICKERING.

Harvard College Observatory,
Circular No. 32.

A Large Meteor was observed here on the evening of July 5th at about 8:50 P. M., 75th meridian time. Apparently starting just below Polaris in Cepheus, it traversed the sky in a southwesterly direction crossing the constellations "Camelopardus," Lynx and finally burst near the horizon in Cancer. Its luster far exceeded that of Venus, when at her greatest brilliancy, leaving behind it a fiery train which was easily visible a greater part of its flight for three or four minutes after the meteor had disappeared. A feeble line of light was lastly seen which, serpent like,—drifted from its direct course into wavy parts, but this gradually faded away and vanished from sight. The space of time occupied in its flight was about four seconds. WESTON WETHERBEE.

Barre Center, N. Y.,
July 6th, 1898.

M. D. Flanery, of Memphis, Tenn., is busily at work observing S Virginis, R Hydræ, SS Cygni and other variables. By the charts he uses it is evident that he is watching some of the interesting variable very closely.

The Bond Chronometers.—The record of Wm. Bond & Sons, 152 State St., Boston, Mass., makers of electric break-circuit chronometers is a surprising one, in view of the great number of their fine chronometers in use, and the Observatories, universities and colleges all over the United States that depend on the Bond chronometers for accurate time service.

Mr. A. Swasey Abroad.—We sometimes need to "travel" in order to know what our neighbors are doing. From the July *Observatory*, in the report of the meeting of the Royal Astronomical Society, June 10, Mr. A. Swasey's remarks before the meeting are given. He said "I have been asked to say something about the work I am interested in, but I hesitate to do so. A work we took up about three years ago was the construction of a dividing engine. Now just as it is much easier to tell the speed of a trotting horse after he has shown it on the track than to say beforehand how fast it will go, so, though it may be easy to say that this engine will divide accurate seconds of arc, to prove it is a more difficult thing. The work we have done with the engine appears to be very satisfactory and well up to our expectations, and I believe there is no error in the engine to exceed a second of arc. We worked for more than a year to reduce the error from a second and a half to a second. I mention this not meaning that we have accomplished more than others, but merely to show that if anyone attempts to construct a dividing engine which will divide less than a second of arc, he has a very difficult job before him."

The New Allegheny Observatory.—It will interest the many friends of Mr. Brashear, acting director of the Allegheny Observatory to know, that he is pushing forward the raising of the deficiency to make the amount $200,000 for the new Observatory at Allegheny. We are told that this amount is already nearly completed. In the past, the old Observatory at Allegheny has been one of the foremost in this country, in results for science, and in the men who have managed it. Its fast friends in Allegheny must not, *will not* let that great Observatory take any backward steps, for the lack of generous support.

Gegenschein and the Zodiacal Light.—We have just received an important communication from A. E. Douglass of Lowell Observatory, in relation to a plan for observations of the Gegenschein and the Zodiacal Light. The suggestions about such work are accompanied by a preliminary zodiacal map, which was made by Mr. Douglass to serve as an observation record sheet.

He hopes shortly to publish a more carefully prepared chart in the form found most convenient by experience and to prepare also a cheap copy of it to serve for recording the observations.

This preliminary map is simply a transference of star positions and approximate magnitudes from Heis' Zodiacal Atlas by means of a "Reducing Chart." This chart consists in a sheet of tracing cloth with longitude and latitude curves for each ten degrees drawn on it so that when the cloth is properly placed on Heis' Map the positions of each star with reference to the lines of longitude and latitude may be seen. As the cloth is transparent it is only necessary for this chart to cover 90 deg. of longitude. It extends 30 deg. on each side of the ecliptic.

In transferring the stars the reducing sheet was secured in its proper position and the prospective map with its ten-degree squares of longitude and latitude already drawn, was placed upon it and by a simple graphic interpolation each star given by Heis was located within its ten-degree square and the form of the star image in Heis' Atlas roughly copied. From a comparison of about 150 stars with Proctor's large Star Atlas it is estimated that the position of nearly every star may be depended upon within a quarter of a degree.

This map is only sent to a few observers who are most interested in the subject.

This scheme is a most worthy one and it is hoped that Mr. Douglass will carry it forward.

The Astrophysical Observatory at Potsdam.—The eleventh volume of the publications of this Observatory, just issued, contains the results of five important investigations.

1. The first is by O. Lohse on "Observations of the South Polar Spot of Mars." Dr. Lohse measured the position angle of the south polar spot on many dates from July 31 to Sept. 26, 1892, and from July 5 to Oct. 12, 1894. From these measures he has deduced the position of the axis of Mars and the node and inclination of the equator of Mars to the plane of the Earth's equator. The following table given by Dr. Lohse at the end of his memoir includes the results of all the previous determinations of the elements of Mars' equator:

Epoch.	Node. °	Inclination. °	Observer.
1782	49.13	42.44	W. Herschel.
1798	50.55	39.23	Schröter.
1833.5	47.57	39.92	Bessel, Oudemans.
1880 0	48.13	36 38	Schiaparelli.
1880.0	47.01	37.50	H. Struve.
1883.0	48.22	36.69	Lohse.
1893.7	48.42	36.18	Lohse.

It is interesting to note the close agreement of the later elements with those of the satellites of Mars as determined by Professor Hall.

Epoch.	Satellite.	Node. °	Inclination. °
1880 0	Phobos	47.24	36.78
1880.0	Deimos	48.11	35.64

2. Dr. J. Scheiner gives the results of the measurements of two photographs of the Orion nebula. These were taken with the photographic refractor which is

being used in the photographic survey of the heavens. The exposures given were 3½ hours and 5 minutes respectively. The second plate was measured by Dr. Plassman as well as by Dr. Scheiner and the separate results for each star are given. A comparison of these separate results shows that the errors of measurement of the plates are extremely small. Comparing the measures of the two plates we find the differences seldom exceed 1″ and that the measures of the fainter stars are the more accurate.

Upon the longer exposed plate Dr. Scheiner found 374 stars with measurable images, the magnitude of the faintest being called 13.5. In the same area Bond with the 15-inch telescope at Cambridge, Mass., charted about 600 stars. A comparison of the identical stars reveals no discrepancies exceeding 20″, but a considerable number above 5″. Nearly all of these refer to stars classed by Bond as very faint and hence may be due to his errors of observation. There is no case of certain proper motion of stars within the nebula established.

Dr. Scheiner has measured the positions of a large number of the brighter points of the nebula, finding the probable error of measurement to be under 1″, so that we have the basis of a future study of the motion of the nebula.

A fairly good reproduction of the 3½ hour photograph accompanies the memoir.

3. Dr. J. Wilsing gives a determination of the parallax of 61 Cygni from the measurement of 77 photographic plates taken on 49 nights during the period Oct. 14, 1890 to Jan. 20, 1892. The exposure upon each plate was 4ᵐ. The comparison stars used for determining the scale value and parallax were:

No.	Argelander's No.	Mag.
1	DM. 38°.4325	6.0
2	37°.4159	7.5
3	37°.4180	7.7
4	37°.4170	8.5
5	37°.4179	8.6
6	37°.4189	7.9
7	37°.4173	8.8
8	38°.4348	9.5

The parallaxes of the two components of 61 Cygni were determined separately from each of the stars numbered 6, 7, and 8, yielding somewhat discrepant results, ranging from 0″.43 to 0″.23. The writer finally adopts as the parallax of the system of 61 Cygni that of the second component as compared with the star 6, $\pi = 0''.357 \pm 0.017$.

4. The fourth part of the volume contains a valuable series of variable star observations by Wilsing during the years 1881 to 1885.

5. The fifth part contains an important "investigation of the absorption of starlight" by Messrs. G. Müller and P. Kempf, which deserves a more extended review than can be given here. In order to obtain their data the observers organized an expedition to Mt. Etna and measured the photometric extinction of the light of certain stars simultaneously at the summit of Mt. Ætna and at Catania, at the foot of the mountain. They found the coefficient of the transmission of light at the summit of the mountain to be 0.880 while that at Catania was only 0.708.

BOOK NOTICES.

Elements of the Differential and Integral Calculus with applications by William S. Hall, Professor of Technical Mathematics in Lafayette College, Second Edition, New York, D. Van Nostrand Company, 1898, pp. 249.

We have been interested of late to notice the number of good books that are appearing in the branches of mathematics for the technical schools and the applications of science generally. In this important work the Calculus is receiving the full share of attention apparently needed for best results.

Professor Hall's revision of his Calculus now before us is fully up to date with a table of contents that is a little stronger than most of the books on Calculus now in use, in the best colleges and universities, especially such as do the work scheduled in the text-books they advertis. The graduation of its subject matter seems to us very excellent, and although the scope covered is large, an instructor will find its methods clear, full, concise and logical. The method of limits, so called, is used in proofs and unusual care taken in explaining and proving the propositions on which this kind of proof depends. The method is probably as good as any, unless it be that of rates which seems to us to have some advantages for beginners over that either of limits or of infinitessimals. After the student is well started, it matters little which way the proofs are applied, they all essentially come to the same result.

Another good feature in this book is the study of the Differential and of the Integral operations side by side. In our experience this is the best way for rapid advancement with best results. The Integral operation is wholly dependent on that of the Differential, and why should not the student take the converse operation at the same time, with the expectation that both methods will be more firmly fixed in mind by so doing?

The applications are to be commended, for they easily introduce the student to the lines of practical use in which the Calculus is a most noble instrument of investigation. The chapter on Differential Equations is just what a student needs if he intends to pursue his studies further.

The special works on this subject are too difficult at the outset for even a good student, and some such preparation as this is very helpful and encouraging.

The publishers have done their part well in finishing a book that is attractively neat in its appearance.

Stories of Starland by Mary Proctor.—Published by Potter & Putnam Company, New York. Cloth, 186 pp. Price 50 cents.

Richard Proctor, the mathematician and astronomer, was widely and favorably known throughout this country as a versatile writer and an able lecturer. His spirit lives through his daughter Miss Mary Proctor, who, as a writer and lecturer to children is establishing herself in the hearts of the people.

From childhood she was her father's constant companion and she absorbed from him a love for his favorite pursuit, as well as a fund of information which she is in turn giving to the children of the land.

As a lecturer she has already achieved a high reputation. She gave a course of popular lectures in Chicago during the World's Columbian Exposition. Since then she has lectured in nearly all the large cities in the United States. Under the auspices of the Board of Education she has delivered nearly fifty lectures on astronomical subjects to the general public in New York City.

Especially is she happy in her talks to children on the wonders of the heavens. She holds the strict attention of her audience of little ones by her simple language and interesting stories and legends, the last of which she seems to have an unlimited supply.

She is also a frequent contributor to periodicals; but Stories of Starland is the first product in book form from her pen.

The great truths of astronomy, about which the average child, and even the adult knows so little, are so clothed and interwoven in story that the reader is led entranced as through a fairy land, by this delightful author. The style is conversational in character and the story is developed and guided by the inquisition and natural questions of her brother Harry and his little cousin Nellie.

The story of the Giant Sun; the Family of Giant Sun; A Ramble on the Moon; The Planet Mars and the Baby Planets; Story of Jupiter and his Moons; The Giant Planets; Comets and Meteors; Stories of the Summer Stars: God Bless the Star, are the main chapter headings. Nearly forty legends are told, some of them appearing in print for the first time. The book is copiously illustrated and at the end of each chapter are appropriate and simple poems.

The typography of the book is most excellent, the binding attractive. It is a book a child will read with pleasure and profit.